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Unveiling the silent struggle: Exploring the influence of dyslexia on elementary students' mathematics learning in Nepal

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Abstract

Dyslexia is a neurodevelopmental disorder characterized by difficulties in accurate and fluent reading, spelling, and writing. The purpose of this study was to evaluate the prevalence of students with suspected dyslexia and its impact on math performance among elementary-level students in Nepal. A mixed-method approach was employed, involving a sample of 1,661 students in grade V and grade VI. The study was conducted in two phases. In the first phase, students with suspected dyslexia were identified using the dyslexia checklist for teachers, dyslexia checklist for parents, and dyslexia self-assessment questionnaire. In the second phase, observation and semi-structured interviews were conducted to verify the suspected students with dyslexia. The study revealed that the incidence of students with suspected dyslexia among elementary school students was 8.97%. Among the students with suspected dyslexia, the occurrence rate was slightly higher in males (10.42%) compared to females (7.90%). Additionally, the researchers assessed the impact of dyslexia by comparing the math test scores between students with suspected dyslexia and those without dyslexia. The results demonstrated significantly lower performance among students with dyslexia compared to their non-dyslexic peers.

Keywords: dyslexia, elementary level, incident, influence, mathematics, Nepal

INTRODUCTION

Background of Study

Dyslexia is a learning disability that is characterized by difficulties in phonological processing, which affects an individual's ability to perceive and manipulate speech and sounds. It is important to note that dyslexia does not impact a person's intelligence, as it is caused by neurobiological differences in the brain and can occur regardless of intelligence level (Kunwar, 2023). External environmental factors, lack of motivation, or a poor learning environment are not the causes of dyslexia (Protopapas, 2019). Dyslexia commonly affects speaking and reading abilities and can also have significant impacts on areas such as working memory and processing speed (Cambridge English Assessment, 2018). Language processing difficulties associated with dyslexia extend to reading, writing, and spelling (Bodrova & Leong, 2017). Dyslexia is a complex condition that varies in severity and manifests uniquely in each individual (Lachmann & Bergström, 2023).

In Nepal, there is limited research on learning disabilities such as dyscalculia and dyslexia (Kunwar, 2023; Thapa, 2023). Additionally, there is a lack of validated tools for targeted diagnosis and dedicated research for students with learning disabilities as a whole (Sharma & Mahapatra, 2019). As dyslexia affects both speaking and writing abilities, difficulties can also arise in understanding and expressing mathematical concepts (Kunwar, 2023). According to Lachmann and Bergström (2023), dyslexia is characterized by difficulties with processing words. Originally referred to as "word blindness," dyslexia is associated with challenges in language processing (Kirby, 2020). The term "dyslexia" is derived from two Greek words: "dis," meaning bad or inadequate, and "lexis," which denotes language. Therefore, dyslexia is characterized by

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Contribution to the literature

- This study contributes to add a literature regarding the prevalence of students with suspected dyslexia and gender differences in the occurrence of suspected dyslexia in an elementary school population in Nepal.
- It explores the impact of dyslexia on mathematics performance, demonstrating that students with suspected dyslexia had significantly lower scores on mathematics tests compared to their non-dyslexic peers.
- It contributes to the process of identifying suspected dyslexic students studying at the elementary school level in Nepal and also provides a set of screening tools for suspected dyslexia.
- The study provides insight into the prevalence and academic challenges faced by elementary school students with dyslexia in the Nepalese educational context, which can contribute to a better understanding of dyslexia in non-Western settings.

impairments in word recognition, phonemic awareness, comprehension, as well as difficulties with rapid naming (Kirby, 2020; Lachmann & Bergström, 2023). Dyslexia encompasses more than just reading; it also involves difficulties in understanding language (Kirby, 2020). It encompasses challenges related to literacy skills and cognition that may create educational disparities (Forrester et al., 2020; Surushkina et al., 2021).

Dyslexia is recognized as a lifelong condition that can persist throughout an individual's lifespan, including into old age (Kirby, 2020; Snowling et al., 2020). The experiences of dyslexia can vary in severity among students (Fletcher et al., 2019; Margaret et al., 2020; Wagner et al., 2019). Some children may encounter difficulties related to language and speech, while others may face challenges specifically related to sounds and symbols (Montgomery, 2017). Dyslexia primarily affects language learning, impacting reading and writing abilities (Kunwar & Sapkota, 2022). However, some children with dyslexia may also experience challenges in math (Forrester et al., 2020; Lambert & Harriss, 2022; Snowling et al., 2020). It primarily affects accurate word reading and comprehension, as well as correct spelling (Lambert & Harriss, 2022; Snowling et al., 2020).

Dyslexia has a significant impact on two key aspects of specific learning disability: phonological encoding difficulties during word building and reading challenges (Grigorenko et al., 2019; Kunwar & Sapkota, 2022), and the reading issues are unexpected (Fletcher et al., 2019). It is influenced by a combination of neurobiological, hereditary, and environmental factors (Peterson et al., 2021; Theodoridou et al., 2021). Dyslexia can be associated with a range of behavioral challenges and difficulties, such as aggression, anxiety, low self-esteem, and challenges in relationships with peers, teachers, and parents, stemming from psychological problems (Wilmot et al., 2022). The extent of dyslexia's impact is directly linked to the development of negative attitudes towards language and math learning (Lambert & Harriss, 2022; Yang et al., 2022). These negative attitudes and concerns often disrupt children's normal learning process. Difficulties in understanding mathematical facts, patterns, and symbols can impede learning and problem-solving in other mathematical subjects (Lambert & Harriss, 2022; Yang et al., 2022).

Dyslexia affects various important areas of learning, such as reading, writing, coordination, attention, memory, language skills, sensory processing, and math abilities (Tiril & Okumus, 2022). Therefore, it can impact the comprehension of mathematical signs, symbols, procedures, and the development of mathematical concepts and skills.

Outline of Dyslexia & Mathematics

Dyslexia has a wide-ranging impact that extends beyond reading skills and affects various areas of learning (Kunwar, 2023; Tiril & Okumus, 2022). Children diagnosed with dyslexia often face difficulties with short-term memory, which can significantly affect their overall academic performance compared to their non-dyslexic peers (Chinn & Ashcroft, 2017; Thapa, 2023). In the field of math, students with dyslexia may struggle to understand mathematical symbols, rules, patterns, and their relationships in arithmetic (Kunwar & Sapkota, 2022). This can lead to challenges in recognizing different mathematical patterns and understanding their relationships. Consequently, dyslexia can impede a learner's ability to comprehend mathematical word problems, understand the relationships within them, and successfully solve them (Almahrag, 2021; Chinn & Ashcroft, 2017).

Dyslexic children often encounter multiple obstacles that can impact their self-confidence and overall academic performance (Chinn & Ashcroft, 2017; Kunwar, 2023; Thapa, 2023). They may experience negative self-image, fear of new situations, confusion with written and verbal instructions, inattentiveness, disorganized thinking, poor stamina, and task avoidance (Lambert & Harriss, 2022). Furthermore, dyslexic learners may struggle with letter and number calculations, acquiring basic skills, and sequential writing, which can hinder their progress in math due to a lack of foundational mathematical skills (Delazer et al., 2019; Peterson et al., 2021). Numeracy, number

sequencing, and higher-order thinking can pose particular challenges for dyslexic children (Lambert & Harriss, 2022). Additionally, difficulties in understanding language can lead to feelings of frustration, decreased motivation, and subsequently, diminished performance in math (Jourdain & Sharma, 2016).

Children with dyslexia often face difficulties in learning math due to slower information processing and cognitive skills (Peterson et al., 2021). They may struggle with specific arithmetic operations, integrating or connecting information, and memorizing math facts (Almahrag, 2021; Lambert & Harriss, 2022). Dyslexic children may encounter challenges with fluent processing, which is crucial for developing literacy skills and building a strong foundation in math (Kunwar & Sapkota, 2022; Lambert & Harriss, 2022). Additionally, their difficulties with memory processing can hinder their ability to multitask while analyzing mathematical tasks simultaneously (Ellis et al., 2020).

Some students with dyslexia may face obstacles in arithmetic, affecting their ability to memorize verbal math facts and multiplication tables (Almahrag, 2021; Lambert & Harriss, 2022). When individuals with dyslexia encounter math problems, their anxiety can be heightened compared to their peers without dyslexia. Research studies have shown that individuals with dyslexia often exhibit higher levels of math anxiety due to the challenges they face in processing numerical information and problem-solving (Kunwar & Sapkota, 2022). Dyslexic students may experience higher levels of math anxiety compared to their non-dyslexic peers due to weaknesses in language skills, word recognition, and decoding skills. These weaknesses can contribute to increased anxiety levels, underscoring the importance of targeted support and interventions for individuals with dyslexia to alleviate math anxiety (Kunwar & Sapkota, 2022). Therefore, it is crucial to provide students with dyslexia the necessary support and accommodations to help them overcome these challenges and achieve success in math.

Incident of Dyslexia

The identification of students with dyslexia is challenging due to measurement error and specific conditions such as the use of arbitrary cut-points, low prevalence rates, and reliance on single criteria (Wagner et al., 2020). Dyslexia presents challenges that extend beyond difficulties in reading and can have significant academic and social implications for students with dyslexia. Volkmer and Schulte-Körne (2018) stated that dyslexic children are at a higher risk of experiencing academic and social problems, which can lead to feelings of depression. This frustration, in turn, contributes to higher levels of reading anxiety (Kunwar & Sapkota, 2022; Lambert & Harriss, 2022).

The incidence of dyslexia varies across regions and countries due to various reasons. Within the United States, it is estimated that dyslexia impacts approximately 5.00% to 17.00% of children, whereas in the United Kingdom, the estimated incidence falls around 7.00% to 10.00% (Cornwell & Shaw, 2023). Similarly, in France, it is estimated to affect 3.50% to 6.60% of the population (Di Folco et al., 2022). Gu et al. (2018) noted that the incidence of dyslexia among school-age children in non-English-speaking countries, such as China, ranges from 3.00% to 12.60%. As suggested by Lin et al. (2020), differences in incidence rates may be attributed to cultural and linguistic factors. The incidence of dyslexia is influenced by gender differences, with a higher prevalence observed among males in comparison to females, estimated at a ratio of approximately 3.4 to 1.0 (Arnett et al., 2017; Kunwar, 2023). This disparity may be influenced by teachers perceiving boys as more disruptive and, therefore, more likely to be referred for special assistance with reading difficulties (Shaywitz et al., 2021).

Dyslexia poses a significant challenge that affects a substantial number of individuals and their families worldwide (Shaywitz et al., 2020). The global incidence of dyslexia is subject to varying estimates, ranging from 5.00% to 20.00% of the population according to Wagner et al. (2020). Thus, it is clear that dyslexia is a widespread issue that requires attention and support (Kunwar, 2023). However, many countries, including Nepal, still face challenges in achieving early identification, intervention, and adequate support for students with dyslexia (Kunwar & Sapkota, 2022; Sharma & Mahapatra, 2019; Thapa, 2023).

Studies conducted in multiple countries indicate that students with dyslexia are at a higher risk of experiencing difficulties in math, particularly in areas such as word problems, reasoning, and abstract and higher-order thinking (Duff et al., 2023; Kunwar & Sapkota, 2022). The incidence of dyslexia differs among languages and countries, and variations in diagnostic criteria and assessment tools may contribute to these disparities (Lin et al., 2020; Maunsell, 2020). Research reports indicate that the incidence of dyslexia ranges from 3.90% to 13.50% in Chinese school students (Lin et al., 2020), while in Indian students, it is reported to be up to 12.57% (Chacko & Vidhukumar, 2020). English-speaking countries have reported an incidence rate of approximately 5.00% to 10.00% for dyslexia among school-aged children and 17.50% among clinic patients (Cavalli et al., 2018).

Despite increasing recognition of hidden learning disabilities like dyslexia in Nepal during the last two decades, there remains a deficiency in targeted initiatives focused on early detection, intervention, and sufficient support for students with dyslexia (Kunwar, 2023; Sharma & Mahapatra, 2019).

Significance of Study

The field of math is widely recognized as a challenging subject (Fritz et al., 2019; Kunwar, 2023). In the specific context of this study, low academic performance in school math is a significant concern within the education sector (NASA, 2019). Math plays a significant role as it exerts a profound influence on multiple facets of human existence (Chand et al., 2021) and serves as a foundational pillar for acquiring knowledge in other domains (Kafata & Mbetwa, 2016). However, dyslexia can significantly impair a child's ability to read, comprehend, spell, write, and perform mathematical tasks (Kunwar, 2023). Students with dyslexia often face difficulties in recalling facts, symbols, and multiplication tables, as well as solving both simple arithmetic and word problems (Almahrag, 2021).

Kunwar and Sharma (2020) emphasize that many students worldwide encounter challenges in learning math, particularly in basic numerical calculations and operations. It is crucial to assess the educational status of students with dyslexia and understand the extent to which it affects their mathematical learning abilities (Kunwar, 2023). Even in the context of Nepal, dyslexia has not gained widespread recognition as a disorder, and a significant portion of the population does not actively seek assistance or support for it (Kunwar, 2023; Sharma & Mahapatra, 2019). In this context, the current study serves as an initial effort to explore the status of students with dyslexia in Nepal, identify their needs, and provide support to enhance their academic achievements. Dyslexia often goes undiagnosed, leaving students struggling with math without understanding the underlying cause of their difficulties. The results of this study could potentially make a valuable contribution to the formulation of policies and guidelines within the education system, aimed at addressing the specific challenges encountered by students with dyslexia. Furthermore, it can shed light on policy gaps that require attention to foster a more inclusive education system.

Objectives of Study

This study is grounded in following set of objectives:

1. To identify the incidence of suspected dyslexia among elementary school students in Nepal.
2. To examine the effects of dyslexia on math achievement at the elementary level in Nepal.

METHODOLOGY

Research Design

This study utilized a mixed-methods design, integrating quantitative and qualitative methodologies to gather comprehensive data. The quantitative method is utilized to examine students with dyslexia using research instruments, while the qualitative method is employed to confirm the diagnosis through the use of observation and interviews as tools. The combination of the holistic approach facilitated a comprehensive understanding of dyslexia by integrating standardized data with rich contextual insights. The integration of these methods enhanced study's validity and reliability.

Population & Sample

This study specifically targeted students attending elementary-level institutional schools in Nepal's Koshi and Bagmati Province. To ensure a representative sample from diverse geographic areas, three districts were purposively chosen from each province: Panchthar, Ilam, and Jhapa from Koshi Province, and Kathmandu, Lalitpur, and Bhaktapur from Bagmati Province. To ensure representation from each district, a simple random sampling method was employed to randomly select five elementary schools from each district. The research sample consisted of 1,661 fifth and sixth-grade students from a total of 30 different schools. The study included a total of 961 girls and 700 boys, all aged between 10 and 13 years old.

Tools Development

Dyslexia identification is a comprehensive process that involves the use of various assessment tools and techniques. It is important to incorporate information from various sources to ensure accurate identification of dyslexia (Wagner et al., 2020). Thus, qualified professionals, such as psychologists and educational specialists, conduct assessments and observations to evaluate an individual's reading, writing, and cognitive skills (American Psychological Association, 2022). Cognitive tests assess specific cognitive abilities such as phonological processing, processing speed, and working memory are frequently impacted in students with dyslexia (Mather & Schneider, 2023). Achievement tests, on the other hand, measure performance in academic areas like reading, spelling, and writing (Mather & Schneider, 2023). Considering an individual's developmental history, educational progress, context of the learner, and family background is also crucial in dyslexia identification. This holistic approach allows professionals to gather comprehensive information and make well-informed diagnoses (Shaywitz et al., 2020). Additionally, a multidimensional approach that includes factors like response to intervention, classroom observations, and teacher reports is utilized to capture the complexity of dyslexia across different domains (Lyon et al., 2003).

It is important to highlight that the accuracy of dyslexia screening can vary depending on the assessment tools employed (Cao & Kim, 2021). Different tools may have distinct strengths and limitations, which can impact the accuracy of dyslexia identification.

Therefore, professionals must carefully select and utilize appropriate and validated assessment tools to ensure accurate and reliable results during the screening process. Taking these facts into consideration, the tools utilized in a similar study conducted by Kunwar (2023) were referenced during the adaptation of the various tools for the Nepalese context. The researcher used the dyslexia checklist for teachers (DCT) (**Appendix A**), the dyslexia checklist for parents (DCP) (**Appendix B**), and the dyslexia self-assessment questionnaire (DSQ) (**Appendix C**) to screen students' dyslexia. They conducted dyslexia screening by considering the majority of attempted behaviors listed in the survey tools. DCT consisted of 32 items covering 7 dyslexia factors. This tool has been adapted from the diagnostic assessment tool of British Dyslexia Association in England. Similarly, the tool, DCP contained 56 items addressing factors related to dyslexia such as reading, writing, read and spell out, math, memory, and comprehension and language communication. This tool has been adapted from the dyslexia Scotland checklist for dyslexic children aged eight-18. When identifying students suspected of having dyslexia, the criteria relied on the presence of a majority of the listed behaviors that were marked or accepted in both DCT and DCP tools. Similarly, the tool DSQ comprises 15 Likert-type items, rated on a four-point scale assigning certain scores on each items. Items one-10 range from "rarely" to "mostly," while items 11-15 range from "easy" to "very difficult." While DSQ primarily emphasizes the features of dyslexic learners, it is worth noting that the responses to numerous questions can also relate to learners with non-dyslexia. This tool has been adapted from the tool designed by British Dyslexia Association to screen for adult dyslexia. In this tool, dyslexia is determined by the obtained score. Students scoring below 45 are classified as probably non-dyslexic, those scoring between 40 and 60 are categorized as mild dyslexia, and scores above 60 are considered severe dyslexia.

To validate these tools after some modification, the surveys and questionnaires underwent translation into the Nepali language and subsequent review by linguists and psychologists. The instruments were then tested at a non-sampled school in Ilam District to establish their validity and reliability. In addition to these quantitative tools, qualitative methods such as observation and semi-structured interviews were employed to verify the students with suspected dyslexia. The observation process involved assessing various aspects such as writing, homework, classwork, math test results, and overall student performance. The semi-structured interviews focused on cognitive skills, speech and sound processing difficulties, variations in languages, reading skill development delays, mathematical symbols and formulas, creativity, and family background. Thus, the holistic approach was used by combining quantitative and qualitative tools, to identify and verify the dyslexic learners.

Data Collection

In this study, data collection involved using multiple tools to gather information about students with dyslexia. Before the collection of data, an orientation program was conducted to familiarize the field researcher with the research objectives, introduce dyslexia, and provide survey instructions to students, parents, grade teachers, and math teachers in selected schools. The data collection process encompassed two distinct phases, with the first phase dedicated to gathering data for screening and diagnosing students with dyslexia. In the second phase, data was collected to verify the students with suspected dyslexia.

Quantitative data was collected using three tools: DCT, DCP, and DSQ. DCT was administered to the grade teacher/math teachers of grade V and grade VI. DCP was distributed to parents through their children with the assistance of the grade teacher. Parents were asked to complete the checklist, and assistance was provided to rate the checklist if needed. DSQ was administered to students with the guidance of the grade teacher and math teachers in their respective classrooms. Then, the completed forms were collected for analysis.

All these quantitative surveys were employed to evaluate the dyslexic traits or behaviors of the students. After analyzing the quantitative data, the students with suspected dyslexia were examined. In the second phase of data collection, student observation, and semi-structured interviews were conducted only for the students with suspected dyslexia on the school premises. The students were interviewed using predetermined interview guidelines. Similarly, the suspected students with dyslexia were observed for one week on the school premises. The purpose of using the interview and observation tools was to reduce biases and obtain additional verification of the presence of dyslexia.

Furthermore, to evaluate the effect of dyslexia on math performance, an achievement test consisting of 25 multiple-choice items was conducted. Each item carried two marks and covered topics such as number and sequence, percentage, profit and loss, fraction, and measurement. The items in the test were related to verbal, numerical, and geometric shape representation, as well as fractions. The achievement test was validated through piloting with students from another school.

Data Analysis Procedures

The quantitative data collected by using the tools DCT, DCP, and DSQ were first analyzed to identify students with dyslexia characteristics. During the screening process, these assessment tools were utilized to identify students with dyslexia by assessing the presence of behaviors listed within the tools. In DSQ

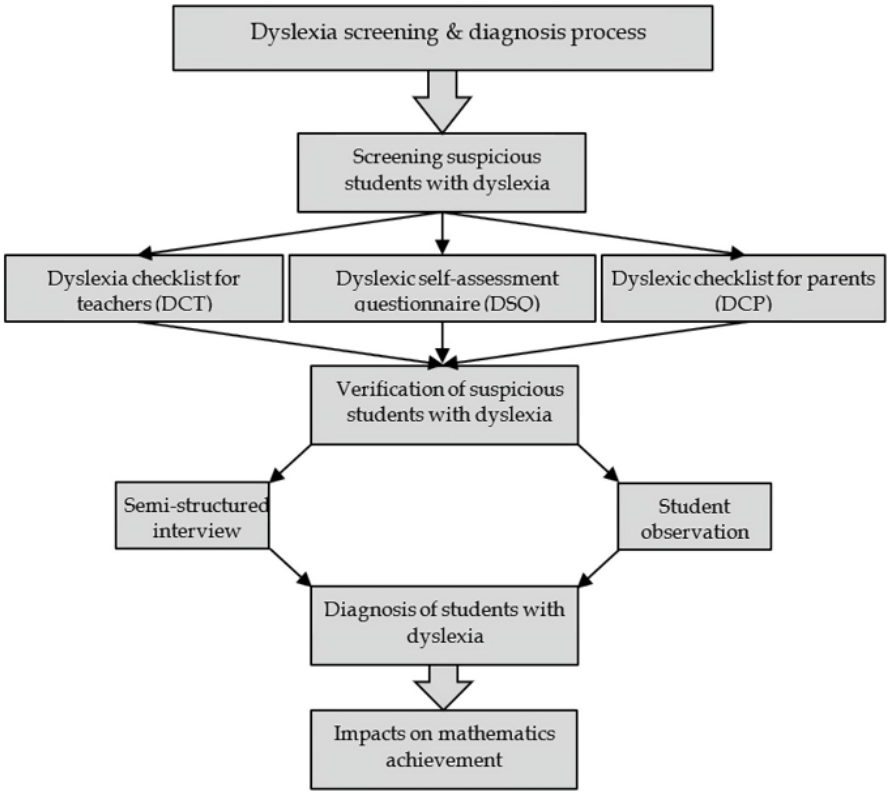

Figure 1. Dyslexia screening & diagnosis flowchart (Source: Authors' own elaboration)

tool, each item has been assigned a specific score corresponding to dyslexic attributes. DSQ tool was designed to determine dyslexia based on a certain range of student scores. By utilizing this scoring system, the students were categorized as either probably dyslexic or non-dyslexic students, which also indicated the severity of their dyslexic characteristics.

Similarly, the scores obtained from DCT and DCP tools were analyzed using the average score as the benchmark. In the second phase, the data gathered from the semi-structured interviews and observations conducted in a natural setting at the school premises were carefully analyzed. During the observation, a checklist of student with dyslexia behaviors was utilized to assess the frequency of their dyslexic behaviors.

Similarly, the responses of the students in the semi-structured interviews were thoroughly analyzed, taking into consideration their family background, academic achievements, and confidence levels. Additionally, the test scores in math from the achievement tests were compared between students with dyslexia and those without dyslexia. The objective of this analysis was to evaluate the influence of dyslexia on students' math learning.

Figure 1 shows dyslexia screening and diagnosis flowchart.

RESULTS

Findings from Quantitative Measures

The data collected from DCT, DCP, and DSQ tools, which indicated potential signs of dyslexia in students, were compiled and organized into a comprehensive list of names. This list incorporated information such as region, school, and gender, enabling a thorough analysis of the results. Overall, the findings about dyslexia characteristics displayed consistency across all three instruments, with minimal overlap in student characteristics. **Table 1** serves as a valuable resource for decision-makers by presenting an overview of students who have been identified as potentially dyslexic by using three different assessment tools.

The findings presented in **Table 1** offer compelling evidence that the dyslexia screening tools utilized in this study were valid and effective in identifying students with dyslexia. This conclusion is supported by the overall consistency in the results obtained from the three tools. While there were a few instances of confusion or inconsistency in student characteristics, the results from DCT and DCP tools showed a reasonable level of similarity to the results obtained from DSQ tool. This further strengthens the effectiveness of these screening tools in identifying dyslexic traits in students.

In this screening stage, a total of 149 students (8.97%) out of 1,661 were identified as doubtful for dyslexia using the three screening tools. Among these students, 76 were female (7.90%) and 73 were male (10.42%).

Table 1. Findings of students with dyslexia from tools DSQ, DCT, & DCP

Schools	Number of students with suspected dyslexia									
	Gender		DSQ		DCT		DCP		Total	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Kathmandu										
Ks_1	34	18	3	3	1	1	2	2	3	3
Ks_2	29	22	2	2	1	1	1	1	2	2
Ks_3	30	27	3	2	2	3	1	1	3	3
Ks_4	32	24	1	3	3	1	2	2	3	3
Ks_5	35	23	3	2	1	2	2	2	3	2
Lalitpur										
Ls_1	36	28	3	2	2	3	1	1	3	3
Ls_2	31	25	2	3	2	1	2	2	2	3
Ls_3	31	29	1	3	2	2	3	1	3	3
Ls_4	27	17	2	1	2	2	2	1	2	2
Ls_5	35	28	2	1	3	3	1	2	3	3
Bhaktapur										
Bs_1	36	28	2	1	3	3	1	2	3	3
Bs_2	32	27	2	3	1	2	3	1	3	3
Bs_3	34	23	2	2	3	1	1	1	3	2
Bs_4	36	29	3	3	-	2	3	1	3	3
Bs_5	29	27	1	3	3	2	2	1	3	3
Panchthar										
Ps_1	34	24	1	2	2	2	3	2	3	2
Ps_2	37	25	2	1	3	2	1	3	3	3
Ps_3	24	22	1	1	1	2	1	1	1	2
Ps_4	34	23	1	2	2	2	1	2	2	2
Ps_5	31	20	2	1	1	1	3	2	3	2
Ilam										
Is_1	33	22	2	1	2	1	2	1	2	1
Is_2	35	26	3	2	2	3	1	1	3	3
Is_3	32	20	-	1	2	1	2	2	2	2
Is_4	24	16	1	1	2	1	1	1	2	1
Is_5	19	12	1	2	2	-	1	2	2	2
Jhapa										
Js_1	32	20	1	-	1	2	1	2	1	2
Js_2	35	24	2	1	2	2	2	3	2	3
Js_3	33	21	1	1	2	1	1	2	2	2
Js_4	34	27	3	-	2	3	1	3	3	3
Js_5	37	23	2	2	1	-	3	2	3	2
Total	961	700	56	53	56	52	51	50	76	73

Findings from Qualitative Measures

In this study, the verification of students with dyslexia was conducted using a multidimensional tool to establish valid and reliable results. This verification process involved directly observing the students in a natural setting, which made it a more authentic, reliable, accurate, and effective method for verifying the data. To validate the findings obtained from the three different quantitative tools regarding students with dyslexia, student observation was utilized. Due to the time limitations, a selective approach was employed in which only students identified as possibly having dyslexia were chosen for observation.

Students who were identified as dyslexic based on all three quantitative assessment tools were excluded from the observation process. Instead, the focus was on observing students who were flagged as dyslexic in one or both of the tools, aiming to verify their dyslexic status.

Similarly, the verification process was conducted to confirm the students with dyslexia who were initially flagged as doubtful based on the results from the quantitative tools. The interviews were conducted in a comfortable setting to encourage open expression from the students. Specific questions relating to dyslexic traits were asked, and active listening and note-taking were utilized to capture their experiences, difficulties, and strengths associated with dyslexia. The responses obtained from the interviews were then compared and analyzed alongside the dyslexic indicators to assess their alignment. To ensure reliability, the interview findings were cross-referenced with other data, including assessments or observations. Through a comprehensive

Table 2. List of suspected students with dyslexia after observation & interview

Schools	Number of students with suspected dyslexia by interview & observation checklist									
	Gender		DSQ		DCT		DCP		Total	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Kathmandu										
Ks_1	34	18	3☑	3-1=❷	1☑	1☑	2☑	2☑	3	2
Ks_2	29	22	2☑	2☑	1☑	1☑	1☑	1☑	2	2
Ks_3	30	27	3☑	2☑	2☑	3-1=❷	1☑	1☑	3	2
Ks_4	32	24	1☑	3-1=❷	3-1=❷	1☑	2☑	2☑	2	2
Ks_5	35	23	3☑	2☑	1☑	2☑	2☑	2☑	3	2
Lalitpur										
Ls_1	36	28	3-1=❷	2☑	2☑	3☑	1☑	1☑	2	3
Ls_2	31	25	2☑	3-1=❷	2☑	1☑	2☑	2☑	2	2
Ls_3	31	29	1☑	3-1=❷	2☑	2☑	3-1=❷	1☑	2	2
Ls_4	27	17	2☑	1☑	2☑	2-1=❶	2☑	1☑	2	1
Ls_5	35	28	2☑	1☑	3☑	3☑	1☑	2☑	3	3
Bhaktapur										
Bs_1	36	28	2☑	1☑	3☑	3☑	1☑	2☑	3	3
Bs_2	32	27	2☑	3☑	1☑	2☑	3-1=❷	1☑	2	3
Bs_3	34	23	2☑	2☑	3☑	1☑	1☑	1☑	3	2
Bs_4	36	29	3☑	3☑	-	2☑	3☑	1☑	3	3
Bs_5	29	27	1☑	3-1=❷	3-1=❷	2☑	2☑	1☑	2	2
Panchthar										
Ps_1	34	24	1☑	2☑	2☑	2☑	3☑	2☑	3	2
Ps_2	37	25	2☑	1☑	3-1=❷	2☑	1☑	3-1=❷	2	2
Ps_3	24	22	1☑	1☑	1☑	2☑	1☑	1☑	1	2
Ps_4	34	23	1☑	2☑	2☑	2☑	1☑	2☑	2	2
Ps_5	31	20	2☑	1☑	1☑	1☑	3-1=❷	2☑	2	2
Ilam										
Is_1	33	22	2☑	1☑	2☑	1☑	2☑	1☑	2	1
Is_2	35	26	3-1=❷	2☑	2☑	3-1=❷	1☑	1☑	2	2
Is_3	32	20	-	1☑	2☑	1☑	2☑	2-1=❶	2	1
Is_4	24	16	1☑	1☑	2-1=❶	1☑	1☑	1☑	1	1
Is_5	19	12	1☑	2-1=❶	2-1=❶	-	1☑	2-1=❶	1	1
Jhapa										
Js_1	32	20	1☑	-	1☑	2☑	1☑	2☑	1	2
Js_2	35	24	2☑	1☑	2☑	2☑	2☑	3-1=❷	2	2
Js_3	33	21	1☑	1☑	2☑	1☑	1☑	2-1=❶	2	1
Js_4	34	27	3☑	-	2☑	3-1=❷	1☑	3-1=❷	3	2
Js_5	37	23	2☑	2☑	1☑	-	3☑	2☑	3	2
Total	961	700	56	53	56	52	51	50	65	60

analysis of the collected information, the dyslexic status of each student was confirmed. Finally, based on the outcomes of the verification process, the students were categorized as either dyslexic or non-dyslexic. This meticulous approach ensured a robust and dependable verification of students with dyslexia through the utilization of semi-structured interviews.

Based on the observation and semi-structured interview reports, the students with uncertainties were categorized as either dyslexic or non-dyslexic. The confirmed students with dyslexia, categorized by gender, can be found in **Table 2**.

As indicated in **Table 2**, a total of 125 students (7.52%) were confirmed as students with dyslexia. Among them, 65 (6.76%) were female students and 60 (8.57%) were male students. The report on student observation and semi-structured interviews played a vital role in confirming the characteristics of dyslexics and behaviors of the doubtful students identified through screening. **Table 2** shows interesting results indicating that the observations and interviews sometimes disagreed with the initial identification of students as dyslexic or non-dyslexic. For instance, there was a male student who, despite not being initially identified as dyslexic using DCP tool, was later confirmed to have dyslexia through observation. Similarly, in certain instances, the observations and interviews corresponded with the findings obtained from the quantitative tools. For example, consider the case of a male student who was initially identified as dyslexic using DCT and DCP tools. Consistency of this identification was confirmed through subsequent observation and interview processes. These findings

Table 3. Incidence rate of students with dyslexia (sex-wise)

Sex	n_1=149	n_2=1,512	Incidence rate (%)	χ^2 statistics	p-value	p
Male	73	627	8.57	3.1499	0.0759	<0.001
Female	76	885	6.76			
Total	149	1,512	7.52			

Note. n_1: Number of students with suspected dyslexia & n_2: Number of students with non-dyslexia

Table 4. Comparison of math achievement between students with dyslexia & students with non-dyslexia

Range of scores	Marks obtained by students with suspected dyslexia		Marks obtained by students with non-dyslexia	
	Male	Female	Male	Female
0-10	44	38	40	22
10-20	21	27	288	369
20-30	5	9	303	373
30-40	3	2	125	119
40-50	-	-	1	2
Total	73	76	627	885

emphasized the importance of considering multiple sources of information for a comprehensive and accurate verification of students with dyslexia.

The processes of observation and interview served to validate and support the initial identification of students in some cases, while in other instances, they presented conflicting results. These findings underscore the importance of utilizing multiple assessment methods to develop a comprehensive understanding of the dyslexic traits and behaviors exhibited by students. Thus, we can ensure a more comprehensive evaluation and enhance the accuracy of identifying students with dyslexia by utilizing various approaches.

Distribution of Dyslexia by Gender

In **Table 3**, we can see the breakdown of students identified with dyslexia based on their gender. Among the 1,661 students included in the study, 125 were diagnosed with dyslexia, indicating an incidence rate of 7.52%. It is worth noting that dyslexia appears to be slightly more prevalent in boys (8.57%) than in girls (6.76%). But when conducting statistical analysis indicated that there is no significant difference between incidence of dyslexia between girls and boys ($p<0.001$). This suggests that sex did not play a significant role in determining incidence of dyslexia among participants. But these figures suggest that dyslexia is slightly more common among male students. Overall, 7.52% of students aged 10 to 13 were found to have dyslexia, indicating incidence of dyslexia within this age range.

Analyzing Mathematics Achievement of Dyslexic Learners

Table 4 presents the math test scores of students, organized by gender and student groups, with a 10-point interval, distinguishing between those with dyslexia and those without. **Table 4** underscores that students with dyslexia tend to achieve lower scores in math compared to their non-dyslexic counterparts. It is worth noting that a significant proportion of students with non-dyslexia also achieved lower scores. However, a few students with dyslexia managed to attain higher marks on the test. The data presented in **Table 4** allows for a direct comparison between the math test scores of students with dyslexia and those with non-dyslexia, emphasizing the greater impact of dyslexia on learning math.

DISCUSSION

Dyslexia is a learning disability that can impact various subjects, including math. The signs and symptoms of dyslexia can differ from one individual to another due to individual differences (Kunwar, 2023). Several typical indicators encompass instances of word skipping and challenges with word recognition, recognizing letters, spelling problems, and reading difficulties (Snowling et al., 2020). These symptoms can emerge during the preschool years, and students diagnosed with dyslexia often exhibit a combination of these features (Kunwar, 2023).

During their early years, students with dyslexia may encounter difficulties in learning the alphabet, recognizing rhyming words, and articulating familiar words (Shaywitz & Shaywitz, 2020). It is important to highlight that dyslexia extends beyond reading and writing, as it can also impact areas such as short-term memory, attention deficit disorder, and motor skills (Snowling et al., 2020). These challenges can have a significant impact on students' overall education, hindering their success in reading, writing, and math (Alghazo et al., 2022; Kunwar, 2023). The incidence of dyslexia is influenced by a multitude of factors, encompassing neurological and genetic factors, cognitive factors, environmental influences, and cultural factors (Chen et al., 2023). This complexity can make identification and diagnosis challenging.

It is noteworthy to highlight that most researchers and experts agree that dyslexia is typically caused by neurological disorders rather than factors such as lack of

motivation, depression, or mental problems (American Psychological Association, 2022; Protopapas, 2019). Understanding and recognizing dyslexia as a specific learning disability is vital to ensuring the provision of appropriate support and interventions for individuals affected by it. To tackle the challenges encountered by students with dyslexia, active participation in educational research is crucial. Diagnostic tools such as cognitive and achievement tests play an important role in identifying dyslexia (Margaret et al., 2020; Mather & Schneider, 2023). However, despite these efforts, students with dyslexia continue to encounter challenges primarily due to a lack of teachers' awareness and insufficient screening processes (Emily, 2020).

However, it's worth noting that the incidence of dyslexia can vary widely, ranging from below 5.00% to as high as 20.00%, as described by Wagner et al. (2020). This variation highlights the need for specialized instruction and support for school-age students who experience reading challenges due to dyslexia (Wagner et al., 2020). Reports on dyslexia incidence within the same country can vary across different locations. Additionally, the incidence rates of dyslexia may differ between male and female students, with a slightly higher incidence often found among males (Kunwar, 2023; Wagner et al., 2020; Yang et al., 2022). In this study, the incidence of dyslexia among elementary school students (7.52%) can be considered as a normal rate when compared to international contexts. Additionally, the higher incidence among males (8.57%) compared to females (6.76%) suggests a common occurrence rate. Similarly, the impact of dyslexia on learning math is considerable. When comparing the achievement scores of students with dyslexia to students with non-dyslexia, it becomes evident that dyslexia significantly affects the learning of math. This highlights the importance of identifying the prevalence of dyslexia on a larger scale. Furthermore, it emphasizes the urgency of providing support and intervention to improve achievement rates, particularly in the subject of math.

As per the research conducted by Thapa (2023), it was estimated that 13.54% of early-grade students in Nepal were at risk of dyslexia and exhibited poor reading skills. Large-scale epidemiological studies investigating dyslexia in Nepal are currently lacking, highlighting a significant gap in the existing research (Sharma & Mahapatra, 2019). However, a small-scale study conducted by Thapa (2018) reported an incidence rate of 12.63% for students at risk of dyslexia based on direct assessment screening. Similarly, small-scale research conducted by Kunwar (2023) in a secondary-level school in Nepal identified 5.53% of students with dyslexia, with a slightly higher incidence among boys students (5.94%) compared to girls students (5.22%). Another study conducted by Yang et al. (2022) reported a worldwide incidence of dyslexia at approximately 7.00%. However, it is noteworthy to acknowledge that dyslexia incidence can vary across populations and regions.

Recognizing the gender differences in dyslexia, the research findings suggest a higher incidence among males. However, it is crucial to approach dyslexia diagnosis and treatment based on individual needs rather than generalizations about gender differences. Early diagnosis and effective treatment of dyslexia are essential for individuals and society as a whole (Kunwar, 2023). Early screening and intervention play a significant role in enhancing outcomes for students with dyslexia, including reading skills, academic performance, and overall well-being (International Dyslexia Association [IDA], 2019; Shaywitz & Shaywitz, 2021).

It is important to acknowledge that dyslexia poses significant challenges for many individuals and their families. Therefore, raising awareness, providing accurate diagnosis, and implementing evidence-based interventions are crucial steps in supporting students with dyslexia and helping them reach their full potential. According to a study conducted by Kunwar (2023), students with dyslexia in Nepal exhibit a notable discrepancy in math achievement when compared to their non-dyslexic peers. Therefore, it is crucial to promptly address the challenges faced by dyslexic learners to improve their performance in math and support the overall education system in Nepalese schools.

Delaying proper interventions for learners struggling with math can lead to frustration and hinder their ability to learn the subject effectively (Lafay et al., 2019). Interventions for dyslexia typically involve a multi-sensory approach that targets the specific difficulties experienced by students with dyslexia. These interventions may include structured literacy programs, explicit phonics instruction, reading comprehension strategies, and the use of accommodations or assistive technologies to support reading and writing (Snowling et al., 2020). If you suspect that you or someone you know may have dyslexia, it is recommended to seek evaluation from a professional, such as a psychologist or education specialist specializing in learning disabilities. These professionals can assess the individual's strengths and challenges, provide a diagnosis if appropriate, and suggest suitable interventions and accommodations to support their educational and personal development (Kunwar, 2023).

CONCLUSIONS

Dyslexia is a learning disability characterized by difficulties primarily impacting reading and writing skills. It can also impact information processing, academic performance, and mathematical abilities. Symptoms of dyslexia include difficulties with attention, processing speed, coordination, multitasking, reading, and comprehension. In this study, the researcher used

various tools including cognitive tests comprising reading, comprehension, and math to diagnose dyslexia. While cognitive tests may not be as precise as neuroimaging or clinical procedures, they provide valuable insights into the location, nature, and causes of dyslexia (Fias et al., 2020). These assessments are valuable tools that help evaluators understand the "what," "how well," and "why" of dyslexia (Mather & Kaufman, 2006). This awareness can inspire teachers and school authorities to identify students with dyslexia and take the necessary steps to implement intervention programs. Dyslexia is a neurobiological problem, and this study has utilized the experiences of teachers and parents to screen students at an early stage.

By doing so, researchers can gain a better understanding of the learner's attitude, behavior, and cognitive profile. This approach allows for a closer examination of the student's unique characteristics. Additionally, this study aimed to ensure more reliable and accurate results by using observation and conducting semi-structured interviews to verify the data. Improving our understanding of dyslexia's prevalence and its effects is crucial for identifying students and implementing targeted intervention programs. Addressing dyslexia can contribute to improved outcomes and help prevent additional academic decline.

The research also highlights how dyslexia influences the mathematical performance of elementary school students in Nepal. It emphasizes the importance of raising awareness and providing support for students with dyslexia in educational settings. This includes early screening, diagnosis, and appropriate interventions to ensure their future success. Understanding how dyslexia specifically impacts math can help develop personalized strategies to improve academic achievement. The research findings can also influence educational policies and practices, promoting inclusivity through the necessary support systems. Moreover, this research contributes to a broader understanding of dyslexia and can inform global interventions and research efforts. Overall, it has the potential to enhance educational outcomes and foster inclusivity for students with dyslexia, not only in Nepal but also in other regions.

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APPENDIX A: DYSLEXIA CHECKLIST FOR PARENT

Students name: Grade: School: Gender:

Please tick (√) at column for "yes" & (×) at column for "no" to each statements given in **Table A1**.

Table A1. Dyslexia checklist for parent

General overview		
When your child reads & spells, do they often:	Yes	No
1. Confuses letters that look similar: Such as *d* and *b*, *u* and *n*, *m* and *n*?		
2. Does your child have good verbal skills, do they like to talk, share what they know and or tell stories?		
3. Is your child always full of ideas about various things?		
4. Do you think your child has a high sense of curiosity and wants to know about things?		
Reading		
Does your child:	Yes	No
5. Read for enjoyment		
6. Read very slowly		
7. Actively avoid reading		
8. Prefer to listen to stories/audio books rather than read them		
9. Find reading difficult and tiring		
10. Misread or misinterpret text or guess a story line or text		
11. Find it hard to say a word correctly (mispronounce)		
12. Have to read text over again to make sense		
13. Have difficulty finding information in a text		
14. Lose the place when reading		
15. Forget the beginning in longer questions		
16. Find it hard to use a dictionary or index		
Writing		
Does your child:	Yes	No
17. Demonstrate a difference in what they can write down and what they can talk about		
18. Actively avoid writing		
19. Confuse words that are similar		
20. Appear to write slowly		
21. Have problems finding the exact word they want to use		
22. Miss out or add in letters of words		
23. Miss out little words		
24. Confuse or reverse letters in a word e.g., b/d; b/p; f/t; n/v		
25. Have messy or illegible handwriting		
26. Have difficulties with spelling		
Numbers/math		
Does your child:	Yes	No
27. Mix up numbers or confuse math symbols		
28. Confuse dates and times		
29. Have difficulty with directions (left/right)		
30. Find it hard to remember tables		
31. Find it hard to get information from graphs and charts		
32. Find mental math very hard		
33. Get muddled when doing a complicated math problem		
34. Have problems reading and understanding math words		
35. Find it hard to remember the order of steps to solve problems		
In general		
Does your child:	Yes	No
36. Mispronounces words		
37. Jumbles up the order of sounds of words, for example 'parcark' instead of 'carpark'		
38. Appear to need more 'thinking time'		
39. Appear excessively tired when they get home from school		
40. Finds it difficult to understand what is expected of them whether that be homework, a class project to be completed at home or an assignment		
41. Struggles to start and/or get through homework, projects or assignments		

Table A1 (Continued). Dyslexia checklist for parent

42. Finds it hard to finish work in time allowed
43. Forgets or loses books and equipment
44. Finds it hard to follow instructions
45. Finds it hard to remember names of objects or people
46. Finds it hard to remember messages
47. Often puts things in the wrong order
48. Has problems judging speed and distance
49. Has poor balance, or appears clumsy
50. Becomes easily distracted
51. Miss deadlines, appointments etc.
52. Tends to bump into things/people
53. Appears/says they feel confused doing tasks that they find hard but feel other people find easier
54. Tries to hide their difficulties from others
55. Lacks self confidence
56. Feels angry and frustrated at times

Parent's signature: Date:

APPENDIX B: DYSLEXIC STUDENTS' CHECKLIST FOR TEACHER

Student name: Class: Gender: M/F

For each student's behavior, please circle response or behaviors that are closest to your own observations.

Table B1. Dyslexic students' checklist for teacher

SN	Dyslexic factors	Rarely	Often
Word reading			
1	Reads slowly.		
2	Trouble sounding-out words.		
3	Mispronounces words when reading stories or text.		
4	Substitutes similar words when reading stories or text.		
5	Omits or adds words when reading stories or text.		
6	Repeats words or phrases when reading stories or text.		
Reading comprehension			
7	Problems learning letter names or letter sounds.		
8	Trouble understanding details, main ideas when he/she reads.		
9	Trouble recognizing cause/effect, conclusions, predictions when reading.		
10	Difficult to memorize words		
11	Reading is hesitant, choppy, or "uneven" when reading stories or text.		
Writing			
12	Written sentences do not make sense.		
13	Trouble preparing an organized written report or story.		
14	Difficult copying from board.		
Communication & language			
15	Difficult to find right/appropriate word		
16	Difficult with following instruction		
17	Need more time to produce sound		
Memory			
18	Difficulty in remembering sequential information, e.g. alphabet, times tables, days of week.		
19	Poor short term and working memory		
Numeracy/math			
20	Trouble with counting and sequencing numbers.		
21	Problems learning names of the numbers.		
22	Trouble learning math symbols (+, -, etc.).		
23	Trouble learning addition or subtraction math facts.		
24	Difficulty learning to carry and borrow.		
25	Trouble learning multiplication math facts.		
26	Trouble completing timed math activities (mad minutes, etc.).		
27	Trouble solving math word problems.		
28	Trouble solving multiple-step word problems.		
29	Difficulty with math involving fractions or decimals.		
30	Trouble with algebra, geometry, or other higher level math.		
Behavior			
31	Low self-esteem		
32	Behavioral difficulty		

APPENDIX C: DYSLEXIA SELF-ASSESSMENT QUESTIONNAIRE

Student name: Class: Gender: M/F Time: 30 minutes

Read questions in **Table C1** & for each question, circle number in box, which is closest to your response.

Table C1. Dyslexia self-assessment questionnaire

SN						
		Rarely	O	Often	MT	Total
1	Do you confuse visually similar words such as cat and cot?	3	6	9	12	
2	Do you lose your place or miss out lines when reading?	2	4	6	8	
3	Do you confuse the names of objects, for example table for chair?	1	2	3	4	
4	Do you have trouble telling left from right?	1	2	3	4	
5	Is map reading or finding your way to a strange place confusing?	1	2	3	4	
6	Do you re-read paragraphs to understand them?	1	2	3	4	
7	Do you get confused when given several instructions at once?	1	2	3	4	
8	Do you make mistakes when taking down telephone messages?	1	2	3	4	
9	Do you find it difficult to find the right word to say?	1	2	3	4	
10	How often do you think of creative solutions to problems?	1	2	3	4	
		Easy	C	D	VD	Total
11	How easy do you find it to sound out words such as Bhudhanilkantha?	3	6	9	12	
12	When writing, do you find it difficult to organize thoughts on paper?	2	4	6	8	
13	Did you learn your multiplication tables easily?	2	4	6	8	
14	How easy do you find it to recite the alphabet?	1	2	3	4	
15	How hard do you find it to read aloud?	1	2	3	4	

Note. O: Occasionally; MT: Most of the time; C: Challenging; D: Difficult; & VD: Very difficult