Asia Pacific Journal of Developmental Differences

Volume 10 ♦ Number 1 ♦ January 2023

DYSLEXIA ASSOCIATION OF SINGAPORE

Published by the Dyslexia Association of Singapore Limited (DAS)

ISSN 2717 5200 (digital)

Contact:

The Managing Editor
Dyslexia Association of Singapore Limited
1 Jurong West Central 2
#05-01, Jurong Point
Singapore 648886

Email: editor@das.org.sg

Asia Pacific Journal of Developmental Differences

Asia Pacific Journal of Developmental Differences
Volume 10 | Number 1 | January 2023

Contents

Asia Pacific Journal of Developmental Differences
Vol. 10, No. 1, January 2023, pp. 1—3

Editorial Comment

Angela J. Fawcett, Editor-in-Chief

It is a very great pleasure to publish this issue of the Asia Pacific Journal of Developmental Differences, published by the Dyslexia Association of Singapore Limited (DAS), which is now in its 10th year of publication. This is a milestone for any journal, and I am pleased to report that the journal goes from strength to strength, addressing major issues in research and practice. In common with most Dyslexia Associations, DAS have extended their reach to include a wider range of developmental differences, including a range of co-morbidities, and this is now clearly reflected in DAS revised mission, "*Helping People with Dyslexia and other Specific Learning Differences Achieve*". We continue to be grateful for the support of our scientific board of reviewers and the international editorial board drawn from both academics and professionals, to reflect the aims of the journal. This enables us to resolve any outstanding issues satisfactorily and ensures we continue to maintain the highest international standards of ethics and professionalism.

In this issue we present articles on a range of topics, with particular emphasis in this edition on Mathematics and on e-learning technology. There has been a strong interest internationally in Dyscalculia, but here we are addressing firstly the progress of children in developing geometric thinking, and secondly the progress of children with dyslexia who have been receiving support in processing problems. The first article, by Dr Mirela Duranovic from Bosnia, addresses an area of Mathematics that has been largely overlooked in the literature. Working with 120 children aged 10, the author identified 11 children with geometric difficulties and found problems in the speed of a range of visuo-spatial tasks in comparison with controls. Adopting a 5-level model of geometric knowledge, the majority of the experimental group fell at level 1 or 2, with improvements linked to levels of understanding rather than age. In the second article on Mathematics, by Aishah Abdullah (Albel) from DAS, the author examines the theoretical underpinning of problem solving, a key area in Singaporean Maths, using Polya's 4 step process and the concrete representational approach in a case study with 8 children with dyslexia. In addition to the rich theoretical background provided, with evidence of improvement for children who adopted the structured approach, a range of outstanding recommendations for practice with children who struggle with problems solving are provided in this interesting article.

In the section on e-learning, a major study by Rosalyn Wee and Serena Tan Abdullah from DAS, with upper secondary and tertiary students with dyslexia, addressed the relevance and effectiveness of the iStudySmart™ approach in improving executive function and essential study skills and techniques. In addition to measuring the impact of the iStudySmart™ programme on these students, their self-confidence, motivation and independence were evaluated in a series of questionnaire, pre, post and after 6 months delay. Positive findings were reinforced by positive comments from parents on the effects of the programme. Impressive results were found for improvements in planning and organisation, writing and presentation. However, although improved, time management and prioritisation required further work to apply in the students' daily lives.

The next article, by Stephanie Ong, Nithyashree Murthy and Soofrina Binte Mubarak from DAS, examined the applications of educational technology in teaching and learning at DAS. Recognising the importance of e-learning for students, particularly following the COVID-19 lockdown, this article examines the impact of teacher's attitudes towards technology in implementing these e-learning programmes. The article considers the use of EduTech in teaching and learning, and the usefulness of the approach, using Technology Adoption Paradigm (TAM). This, the first article of two, considers how 8 educational therapists at DAS interacted with new technology, identifying clear differences in the ease and competence of individuals related to age and experience. In the follow-up study, to be published in the next issue of APJDD, we will see whether their advocacy of technology, low, middle or high, is reflected in the scores of the children they teach. Finally, another study from Soofrina Binte Mubarak at DAS examines the theoretical underpinning of technology, to identify and evaluate three training needs analysis models, to identify gaps in provision, analysing training needs to improve planning, decision making and problem-solving initiatives. The author proposes a new integrated model, which will be examined in greater detail in the second part of this article, in preparation, to be published in the next issue of APJDD. We look forward with great interest to reading more about these highly relevant topics in e-learning and technology.

In the final section of this issue two further articles are presented, one from Dr Margaret Meehan, a former colleague at Swansea University and myself on the impact of bilingualism. This is an interesting topic that has variously claimed improved executive function for the bilingual as opposed to delay in early learning. In order to evaluate the impact of working in Welsh, a comparison was made of performance for students with dyslexia and controls in both Welsh and English. The initial pilot study identified that the Welsh wordchains stimuli were much longer than the English, thus increasing the level of difficulty. In the final study, we found that the Welsh students with dyslexia were slowest at identifying the individual words when presented as a chain, with Welsh non-dyslexics and English-speaking dyslexics almost equivalent to each other, and finally English controls achieving the fastest results overall. The article also includes a case study of a Welsh student and the impact of language on their dyslexia is presented, with

implications for bilingual students worldwide.

The last article in this issue, from Rima Natasha Hartanto, Dyah Ayu Palupi, Ersita Sari and Ayu Yowanda, from the Dyslexia Association of Indonesia, presents an interesting case study on the long-term emotional difficulties experienced by a child with dyslexia. Originally identified at age 3, showing problems with separation, language and following instructions, it was decided that no further therapy was needed. However, dyslexia was finally diagnosed at age 9, and there was emerging evidence for a range of other disorders, including ADHD, language and social skills-based diagnoses such as autism. The article follows the boy's progress over a series of intense interventions targeting different aspects of his behaviour, from learning to social and emotional aspects. The authors recommend the need for a more comprehensive approach to diagnosis, to identify the co-morbidities that exist between conditions, and to examine the consequences of continued failure on long term outcomes. This is an interesting and important study on the need for consistent and ongoing support for these children.

In conclusion, let me wish you all a Happy and Healthy 2023, with the opportunities to apply the lessons we have learned during COVID, in a period of lower infections where the strengths of these new approaches can be fully exploited, in addition to our pre-COVID expertise. I look forward to bringing you the next issue of this journal and further opportunities for updating our knowledge and understanding of the complexities of the area of developmental differences.

Asia Pacific Journal of Developmental Differences
Vol. 10, No. 1, January 2023 pp. 5– 26
DOI: 10.3850/S2345734123000182

Prevalence and characteristics of geometric difficulties in elementary school children

Mirela Duranovic[1*] and Edna Didic[1]

1. *University of Tuzla, Bosnia & Herzegovina*

Abstract

The current study aimed to analyze the prevalence and characteristics of geometric difficulties in elementary school children. In cooperation with teachers, tasks for assessing geometric knowledge, respecting the curriculum for a particular grade, have been developed. The level of geometric thinking was analyzed as an additional factor for classifying geometric difficulties and for better understanding problems that can lead to determining appropriate accommodations. The prevalence of geometric difficulties was 9.2% and students with geometric difficulties were on the first and second level of geometric thinking. Deficits in visual-spatial skills have been also analyzed as potential risk factor for developing geometric difficulties.

Keywords: geometry, geometric level, geometric difficulties, visual-spatial perception, visual working memory

* *Correspondence to:*
Dr Mirela Duranovic, Department of Speech and Language Pathology of the Faculty of Education and Rehabilitation, University of Tuzla, Bosnia & Herzegovina. Email: mirela.duranovic@gmail.com

INTRODUCTION

Mathematical thinking is involved in almost all aspects of modern life. Consequently, people with poor mathematical skills have problems graduating high school, going to college, having a steady job (Bynner & Parsons, 2006). It is estimated that 3–6% of the population suffer from the specific mathematics learning disability called developmental dyscalculia (DD) (Badian, 1999; Gross-Tsur et al., 1996). The latest DSM-V diagnostic criteria define DD as a neurodevelopmental disorder characterized by difficulty in learning about numbers and arithmetic, which manifests in children despite adequate neurological development, intellectual abilities and schooling opportunity (American Psychiatric Association, 2013). Individuals with DD exhibit an inability to place basic arithmetic information in long-term memory, to understand or access quantities connected with number words and Arabic numerals, and have problems in learning arithmetic procedures (Butterworth, Varma & Laurillard, 2011; Mazzocco, Feigenson & Halberda, 2011).

There are four basic areas of mathematical skills: number processing; arithmetical procedures; arithmetic facts retrieval; and geometrical abilities (Dehaene, 1997; Geary & Hoard, 2001; McCloskey, 1992; Rubinsten & Henik, 2009; Von Aster & Shalev, 2007), with different cognitive and neural correlates, different influences of neurological processes and environmental factors, leading to different subtypes of DD (Pedemonte et al., 2022).

Karagiannaki, Baccaglini-Frank and Papadatos (2014) proposed a classification model for mathematical learning difficulty, including four subtypes: core number, memory (retrieval and processing), reasoning and visual-spatial. The Visual-spatial subtype includes the domains of written arithmetic, geometry, algebra, analytical geometry and calculus (Geary, 1993, 2004; Mammarella et al., 2010; Rourke & Conway, 1997; Venneri et al., 2003).

Although geometry is the part of mathematics in which the properties of space and objects in space were originally studied (Volenac, 1979), fundamental components of mathematics learning (Final Report of the National Mathematics Advisory Panel, 2008), less attention was paid to it in research on mathematical difficulties. In a systematic review of mathematics interventions for students with learning disabilities (Maccini, Mulcahy, & Wilson, 2007), only one study (see Cass et al., 2003) included achievements in geometry. No research about interventions in geometry was found in a meta-analysis of studies of mathematics interventions for elementary students with special needs (Kroesbergen & Van Luit, 2003). Chew and Lim (2013) pointed out the importance of learning geometry as a basic skill for learning other topics in mathematics such as fractions, decimals, percentage, functions and calculus. For appropriate knowledge in mathematics and science, all children should learn geometric shapes and spatial relationships, use visualization and spatial reasoning to transform shapes, and apply geometric modeling to solve problems (NCTM, 2000), therefore geometry should not be ignored.

Wong, Hsu, Wu, Lee, and Hsu (2007) noted that geometry is more difficult than other mathematics areas and geometric problem solving can be especially challenging for students because of problems with the comprehension of geometric problems. Therefore, a very important question that needs to be open is do we have children with geometric difficulties in schools, what criteria to use to classify geometric difficulties, what is the prevalence of geometric difficulties and which risk factors lie behind these difficulties. The current study tried to find answers to all of these questions.

Prevalence of Mathematic Disorder

Knowledge of the prevalence of learning disabilities enables the determination of the extent of learning disabilities in the normal population of school children, recognition of risk factors, and helps develop therapeutic strategies. The law requires the provision of services for individuals with learning disabilities, and public health issues are also important. Data on prevalence, relative risk, outcome, and effective therapeutic procedures are necessary to make appropriate decisions to secure the resources needed for medical and educational services (Hammill, 1990).

To determine prevalence we must develop a scientific and clinical consensus as to what constitutes a learning disability and which definition best describes the problem. Prevalence studies on DD have been carried out in various countries using different definitions. In spite of the lack of definitional consistency, the prevalence of DD across countries is relatively uniform, ranging from 3-6 % in the normal population (Shalev, Auerbach, Manor & Gross-Tsur, 2000). Kosc (1974) in Bratislava and Badian (1983) in American children found prevelance at 6.4 %. In England 1.3 % children had a specific arithmetic disability and 2.3 % arithmetic and reading disabilities (Lewis, Hitch & Walker, 1994).

Geometry is, with arithmetic, one of the oldest branches of mathematics. It is concerned with properties of space that are related with distance, shape, size, and relative position of figures (De Risi, 2015). Geometry encompasses many wider areas of problems, practical and abstract, which may have practical application (Volenac, 1979). Learning geometry helps students to develop skills such as visualization, critical thinking, intuition, perspective, guessing, deductive reasoning, logical reasoning, and proving (Šutalo, 2016). Learning disability can include mathematics difficulties which result from problems in cognitive skills that have influence on student's ability to represent or process information in one or all of the mathematical domains, such as geometry (Geary, 2004). It has been noted that deficits in geometric abilities can be manifested by visuo-perceptual mistakes in symbol processing, arranging numbers for written calculations, understanding graphs and figures, and identification of visual characteristics of objects (Geary, 1993). Symptoms can be manifested in the processing of visual-spatial information, including spatial orientation, directions and distances, and the transformation of three-dimensional objects (Kinach, 2012; Simic et al., 2013).

Knowing the prevalence of geometric difficulties would be of great importance and would have a variety of clinical, educational, and public health implications. Determining prevalence would help in analyzing the success of educational programs and teaching methods. It would be important for agencies responsible for providing medical services and special educational interventions (Shalev, 2007).
t

The Theory of the Level of Geometric Thinking

The model that the best defines student levels of geometric thinking level is based on Van Hiele's model (Battista, 2002). The theory of the Dutchman Pierre van Hiel explains why a large number of students have problems with geometry, especially with formal proofs. His theory consists of five levels of thinking through which students will gain the ability to perform formal evidence and understanding (Ovčar, 1990). At each subsequent level, new knowledge is acquired, and in order to reach the next level, it is necessary to adopt the previous one. It depends solely on the understanding of a particular material and the perception of the whole concept, and not only on the acquisition of factual knowledge. Also, age does not affect the transition to the next level. There are people who have remained at the initial level throughout their lives despite going through the school system within which geometric content was processed (van Hiele, 1986).

According to Van Hiele (1986), five levels have been explained:

- **Level 1 - Visualization Level.** Students, at that level, make decisions based solely on the basis of perception, without knowing any reason. They are able to recognize geometric shapes, such as: triangle, quadrilateral or circle, but their properties are not known to them, and they often believe that something is just like that based on one example only.

- **Level 2 - Level of Analysis.** Students, at this level, see figures as a set of properties, and learn terms to describe them, but they still cannot see the connection between them. When describing an object, they list all its properties, but they cannot distinguish - which of them are necessary and which are sufficient to describe it. They can draw conclusions inductively, based on a few examples, but they still cannot use deduction. They begin to believe that if a figure belongs to a class of squares, then it has all the properties of that class, such as, for example: mutually normal diagonals, sides of equal length, right angles, lines of symmetry, and other properties.

- **Level 3 - The Level of Abstraction**, **or the Level of Informal Deduction.** Students learn about the relationships between the properties of geometric shapes and, based on that, the relationships between the geometric shapes themselves. They begin to think deductively, but do not yet understand the rule and meaning of formal deduction. At this level, students begin to think about what is needed and

what is enough to describe a geometric figure. For example, they know that it is enough that a quadrilateral, which has all sides equal, has one right angle, to be a square.

- **Level 4 - Deduction Level.** Students can derive high school-level evidence, draw conclusions from previously known claims, understand the meaning of definitions and axioms, and understand the meaning of a necessary and sufficient condition. Students are able to use abstract concepts, and to draw conclusions that are based more on logic than on intuition.

- **Level 5 - Level of Strictness.** At this level, older students are able to understand the consistency, independence and completeness of the axiomatic system, and to compare mathematical systems. They can also understand indirect proof - proof using contraposition, and understand non-Euclidean geometric systems.

In the original works van Hiele's numbers were numbered from 0 to 4, while in some American theories based on van Hiele's theory the levels are numbered from 1 to 5, while level 0 is complete ignorance of any form of geometry (Crnjac, 2013). The order of the levels of thinking that students go through is invariant, on the way to the highest level, no previous level can be skipped which was shown in the studies conducted by Burger and Shaughnessy (1986), and Fuys, Geddes and Tischler (1988).

It is difficult to determine the time it takes to move from one level to the next, because only active learning and work on understanding the material is important, and some need more and some less time (Crnjac, 2013). According to van Hiele's theory, the main reason why a traditional curriculum fails is that it is presented at a higher level than that at which students function. In other words, students do not understand the professor, nor does the professor understand why students do not understand him (De Villiers, 2008).

It is desirable to examine the level of students, so that they are not taught material that they are not able to adopt, even if they make an effort and listen. This can be done with the tests which are intended for assessing knowledge needed for each level (Bilbija, Milanković & Runjić, 2009). This study had intention to analyze at what level are students in elementary school, especially students with geometric difficulties.

Visual and Spatial Domain and Achievement in Geometry

Mathematics is very complex and includes different areas that integrate different abilities related to the sense of quantity, symbols decoding, memory, visuospatial capacity, logics, to name a few. Problem in any of these abilities may lead to mathematical learning difficulties (Karagiannakis, Baccaglini-Frank & Papadatos, 2014).

The connection between visuospatial skills and mathematics learning disabilities has not been sufficiently explored (Geary, 2004). Studies were mostly caried out with adult or neuropsychological populations, and using that result with the developing skills of children must be made with caution (Bull, Johnston, & Roy, 1999). Visuospatial areas support different mathematical competencies, including the specific domain of geometry and the solving of complex word problems (Dehaene et al., 1999; Geary, 1996). Therefore, problems in visuospatial skills could affect the occurrence of a corresponding learning disability (Geary, 2004).

Karagiannakis et al., (2014) analyzed the literature as well as unpublished clinical observations and proposed a classification model for mathematical difficulties. Four basic cognitive domains have been described including visual-spatial as subtypes. Geometry was connected only with deficits in visuo-spatial working memory and the reasoning/ perception specific systems. For this reason, it is very important to study the relationship between visual spatial working memory (and a particular visual-spatial domain) and achievement in geometry.

Geometry in teaching is the best tool for developing mathematical thinking (Jozić, 2008). It provides students with an aspect of mathematical thinking that is different from the world of numbers, but also related to it. As students become familiar with characters, bodies, locations, transformations, and develop spatial thinking, a foundation is laid for understanding not only the spatial world but also other topics in mathematics and the arts, science, and social research (Razel & Eylon, 1991).

Working memory is a system of limited capacity that allows temporary storage and manipulation of information (Baddeley, 2000). Giofrè, Mammarella, Ronconi, and Cornoldi, (2013) have shown that working memory can be associated with geometric achievements in late adolescence. Numerous studies have shown that working memory predicts success in school, on tasks such as reading comprehension (Daneman & Carpenter, 1980), mathematical success and arithmetic problem solving (Passolunghi & Pazzaglia, 2004). Previous research has shown that geometry includes visual-spatial working memory, the ability to retain and manipulate visuospatial information (Giofrè, Mammarella, Ronconi, & Cornoldi, 2013).

Visuospatial working memory can predict a person's success in geometry-related activities. Geometric problems usually require determining a solution for the problem and this ability refers to higher order control (Clements & Battista, 1992). In fact, visuospatial abilities, are very important in geometric achievements. Also, some researchers have shown that children with mathematical difficuties experience deficits in visuo-spatial sketchpad (e.g., Cai et al., 2013; D'Amico & Guarnera, 2005; McLean & Hitch, 1999).

Purpose of the Study

In order to better understand geometric difficulties in elementary school children, the aim of this study was to determine the prevalence of geometric difficulties in students from third to fifth grade of elementary school, their geometric level, and the relationship between visual-spatial perception, working memory and achievement in geometry. We hypothesized that the prevalence of geometric difficulties will be comparable to the already known prevalence of mathematical difficulties, geometric level would be appropriate additional factor in the determination of children who have geometric difficulties, and visual and spatial deficits are risk factors for developing geometric difficulties.

METHOD

Sample

The study included 120 students from primary schools, 65 boys and 55 girls, aged 9 to 11 years (from third to fifth grade). Random sampling was used as a technique in which each sample has an equal probability of being selected. A randomly selected sample should be an unbiased representation of the total population.

First, 120 students were tested with the aim of determination those who have difficulties in geometry. Eleven children were determined to have geometric difficulties. After that the control group of 11 participants was randomly selected, and consisted of children the same age and gender as the group of students with geometric difficulties. The research was conducted in primary schools in the Brčko District in Bosnia and Herzegovina. The subjects were examined individually in quiet room.

A Raven's progressive color matrix test (PMBs) (Raven, 1956) was used by a qualified psychologist with the aim of excluding children with intellectual disabilities. PMBs are one of the standard tests of nonverbal intelligence. PMBs consists of three series with 12 items: A, AB and B. Within each series, the items are approximately ranked by difficulty, so that they are organized from easier to harder tasks. The task of the respondents is to choose the item that completes the "empty" part of matrix from the offered answers. The time of testing was not limited. No children with intellectual disabilities were found.

Instrument

The Test for assessing geometry skills was prepared according to the curriculum for a given class in cooperation with the teacher. A team of elementary school teachers prepared, reviewed the test and and agreed regarding the most suitable items. Each of the tests, for a particular grade (the third, the fourth and the fifth grade), contained of 10

tasks. Participants had to choose the correct answer, complete the answer or connect the correct answers. The test included the different tasks for different grades, for the third grade: lines, marking a line, circle, diameter, and angles; for the fourth grade: line, length, mathematical signs, angle, triangle, and circumference; for the fifth grade: area of squares, rectangles, squares and cubes, conversion of units of measurement, and geometric bodies (See tests in Appendix A). Two standard deviations below the age-specific mean was used as deficit criteria.

On the test for assessing geometry skills, the students who scored below two standard deviations of the mean performance were classified as having difficulties in geometry. In total, 11 students were determined as those with geometric difficulties. (See Table 1 for participant characteristics and group differences).

Table 1. Test Scores for Children With and Without Geometric Difficulties

Variable	students without geometric difficulties		students with geometric difficulties		F	p
	M	SD	M	SD		
Age	10.76	.72	10.74	.78	.00	NS
Geometric skills[a]	6.73	1.27	2.00	1.00	93.89	<.001
IQ[b]	32.18	1.94	31.36	1.91	.99	NS

Note. Test for assessing geometric skills; bIQ, average of individual intelligence quotients according to the Standard Progressive Matrices Test.

The next task included a geometry test that covers all 5 stages of the development of geometric thinking based on Van Hiele model (1986). The test included the following tasks: basic geometric shapes that students should recognize; basic geometric shapes by which students should determine properties or attributes, type, classify and draw them; tasks in which students are able to establish relationships between the properties of shapes, recognize similar shapes, make assumptions and intuitively make simple conclusions; a task that determines whether children understand the meaning of definitions and axioms, make conclusions from previously known statements; a task to determine whether children are able to form connected sets of conclusions and thus justify their thinking, to show whether they can make conclusions. Each level has five questions. If the students answers three or more questions correctly, they have reached the particular level. The same criteria was used by Usiskin(1982) with the passing rate at 60%.

After seven days from the first part of testing, the second part of the research was conducted, which included nine tasks presented in the Psychology Experiment Building Language (PEBL software, Mueller & Piper, 2014; Mueller & Esposito, 2014), related to visual-spatial perception and visual memory. The tests are freely modifiable and available via the GNU Public License, Version 3 (GPLv3). The average examination time for one student was 45 minutes.

The Bivalent Shape Task (BST) was used for testing the ability of visual-spatial perception. One shape, a blue circle or a red square, appears in the middle of the screen. The test required from the participant to determine whether a shape at the center of the screen is a circle or square. Circles are always responded to with the left response, and squares are always responded to with the right response. Visual response cues are provided below the stimulus, indicating the side of the response. However, these response cues are shaded in either red or blue. In all cases, color is irrelevant and not used to make the decision. The stimulus shape is presented either in red, blue, or an unfilled black outline. Thus, three basic trial types exist: congruent trials, in which the irrelevant color of the stimulus matches the response cue; neutral, in which the stimulus is black and white, and incongruent, in which the (irrelevant) color mismatches the response cue. Dependent measures of interest are the speed and accuracy with which participants are able to make the decision (Mueller & Esposito, 2014).

The Clock Test is a test of sustained visual attention. It is an implementation of the so-called "Mackworth Clock Task". Participants have to watch a clock and determine when it skips a beat. The Mackworth Clock is an experimental device used in the field of exerimental psychology to study the effects of long term vigilance on the detection of signals (Mackworth, 1948).

The Corsi block-tapping test is a psychological test that assesses visual-spatial short term working memory. It involves mimicking a researcher as they tap a sequence of up to nine identical spatially separated blocks. The sequence starts out simple, usually using two blocks, but becomes more complex until the subject's performance suffers. This number is known as the Corsi Span, and average is about 5-6 for normal human subjects (Kessels et al., 2000).

The Line judgment task assesses the ability of visual-spatial perception. The student had to determine which of the two lines is longer, pressing the button on the left or the right side. There was a time limit, the red timer measured the time.

Luck and Vogel's multi-object visual working memory task addressed the measurement in the change detection paradigm, popularized by Luck and Vogel (1997). Participants had to detect a change in a visual display containing a varying number of items. Although there were dozens of versions of the task using different types of stimuli, the most popular version (colored shapes) has been implemented in PEBL. The student had to

remember the screen full of shapes in different colors. Color shapes appeared on the screen, then disappear and reappear. The new screen could be the same as the previous one or different. The student had to determine whether a difference has occurred or the shapes have remained the same.

The Object judgment test was described in Mueller (2010). The test briefly displays a randomly-generated Attneave shape (see Attneave & Arnoult, 1956; Collin & McMullen, 2002), and after a brief interval, the participant must choose which of two alternative shapes was presented: the original or a slightly altered foil. In this task the ability of visual memory is examined. A figure is displayed on the screen, the student should remember it, because the display disappears, and then a couple of figures is displayed. One of the new figures is identical to the previous one; others are different in size, position. The student should choose the one that is identical to the previous one.

The Mental rotation test examines the ability of visual-spatial perception. It is a simple implementation of Shepard and Metzler's classic mental rotation task (1971). Images of two three-dimensional objects rotated in space are presented. Participants decided whether two images matched or not regardless of their orientation.

RESULTS

One of the goals of the study was to determine the percentage of students with geometric difficulties among elementary school children from the third to the fifth grade. Testing included 120 children. Results showed that 11 students scored below two standard deviations of the mean performance of the controls on the test for assessing geometry skills and they were determined as children with difficulties in geometry. It was noted that 9.2% of elementary school children from the third to the fifth grade had a geometric difficulty. As children get older, difficulties became more pronounced. Among children with geometric difficulties 46% of them were in the fifth grade, 36% in the fourth grade and 18% in the third grade. Most children could solve only one or two tasks, although these tasks have been prepared together with teachers in accordance with the curriculum for a particular class.

The Mean for reaction time on the tasks of the ability of visual-spatial perception and visual memory of children with geometric difficulties and scores produced by the control group are shown in Table 2. A One-way ANOVA was undertaken separately for each task, involving the two groups. It can be seen that the performance of the children with geometric difficulties was slower than that of the controls, for the Bivalent Shape Task that tests the ability of visual - spatial perception, the Corsi block-tapping test that assesses visual-spatial short term working memory and Luck and Vogel's multi-object visual working memory task, but reaction time was faster on the Clock Test of sustained visual attention. No significant effects in reaction time have been found on other tasks. Table 3 shows the accuracy on the tasks of the ability of visual-spatial perception and

Table 2. Mean performance for reaction time in milliseconds on the tasks of the ability of visual-spatial perception and visual memory

	students without geometric difficulties		students with geometric difficulties		F	p
	M	SD	M	SD		
BST	1265.47	638.56	1736.12	830.49	F(1.44)=44.40	<.001
Clocktest	388.78	150.08	354.99	148.84	F(1.44)= 75.64	<.05
Linejudgment	1443.79	836.79	1498.05	1137.96	F(1.44)= .33	NS
Rotation	1320.42	810.02	1473.30	838.10	F(1.44)= 3.79	NS
Corsi	4196.89	1566.74	4841.12	1961.93	F(1.24)=8.12	<.01
Luckvogel	1217.68	611.58	1421.62	992.91	F(1.33)= 5.05	<.05
Objectjudgment	1438.28	890.52	1375.41	1094.19	F(1.44)= .44	NS

visual memory of children with geometric difficulties and the control group, and differences based on the chi-square test. There was significant difference in all tasks between the two groups except on the Corsi block-tapping test. In the group of children with geometric difficulties less correct answers were made than in the control group.

In Table 4 a linear regression analysis was performed to find out which of the visual-spatial perception and visual memory skills (covariates) predicted for the group variable (geometric difficulties vs. skilled geometry skills). Results showed that the geometry skills were primarily explained by the correct answer in the task mental rotation which measures the ability of visual-spatial perception (change of variance = 28.0 %, $p < 0.001$), the correct answer for the object judgment test which measures visual memory (change

Table 3. Accuracy on the tasks of the ability of visual-spatial perception and visual memory

Variables	students without geometric difficulties		students with geometric difficulties		X^2	p
	N (%)		N (%)			
	incorrect	correct	incorrect	correct		
BST	35 (15.9)	185 (84.1)	108 (49.1)	112 (50.9)	55.21	<.001
Clocktest	57 (25.9)	163 (74.1)	141 (64.1)	79 (35.9)	64.79	<.001
Linejudgment	33 (15.0)	187 (85.0)	122 (55.5)	98 (44.5)	78.90	<.001
Rotation	53 (24.1)	167 (75.9)	170 (77.3)	50 (22.7)	124.47	<.001
Corsi	37 (27.8)	96 (72.2)	35 (31.0)	78 (69.0)	.29	NS
Luckvogel	22 (13.3)	143 (86.7)	95 (57.6)	70 (42.4)	70.57	<.001
Objectjudgment	39 (17.7)	181 (82.3)	153 (69.5)	67 (30.5)	120.09	<.001

of variance = 27.0 %, $p < 0.001$), the correct answer for the Luck and Vogel's multi-object visual working memory task (change of variance = 21.0 %, $p < 0.001$), the correct answer for the line judgment task which assesses the ability of visual-spatial perception (change of variance = 18.0 %, $p < 0.001$), the correct answer for the Clock Test which was a test of sustained visual attention (change of variance = 15.0 %, $p < 0.001$), the correct answer for the BST which tests the ability of visual-spatial perception (change of variance = 13.0 %, $p < 0.001$), the reaction time for the BST which tests the ability of visual-spatial perception (change of variance = 9.0 %, $p < 0.001$), the reaction time for the Corsi block-tapping test that assesses visual-spatial short term working memory (change of variance = 3.0 %, $p < 0.05$), the reaction time for the Luck and Vogel's multi-object visual working memory task (change of variance = 2.0 %, $p < 0.05$), and the reaction time for the Clock Test (change of variance = 1.0 %, $p < 0.05$).

Table 4. Linear regression for the dependent group variable and the covariates (visual-spatial perception and visual memory measures)

Predictors	Change of R^2	β	B	SE_B	t	p
BST (rt)	.09	.00	.30	.00	6.66	.00
BST (correct answer)	.13	-.35	-.38	.05	-7.93	.00
Clocktest (rt)	.01	-.11	.00	.00	-2.37	.02
Clocktest (correct answer)	.15	-.38	-.39	.04	-8.70	.00
Linejudgment (rt)	.00	.03	.00	.00	.57	.57
Linejudgment (correct answer)	.18	-.42	-.44	.05	-9.78	.00
Rotation (rt)	.01	.09	.00	.00	1.95	.052
Rotation (correct answer)	.28	-.53	-.53	.04	-13.14	.00
Corsi (rt)	.03	.18	.00	.00	2.86	.01
Corsi (correct answer)	.00	-.04	-.04	.07	-.54	.59
Luckvogel (rt)	.02	.12	.00	.00	2.25	.03
Luckvogel (correct answer)	.21	-.46	-.48	.05	-9.45	.00
Objectjudgment (rt)	.00	-.03	.00	.00	-.66	.51
Objectjudgment (correct answer)	.27	-.52	-.53	.04	-12.82	.00

Table 5 shows the level of geometric thinking of students with geometric difficulties, as well as students without geometric difficulties. At the first level of geometric thinking were 45.5% of students, while at the second level of geometric thinking were 54.5% of students with geometric difficulties. Thus, students with geometric difficulties were at the first and

second level of geometric thinking. Furthermore, 81.8% of students without geometric difficulties were at the third level of geometric thinking. At the fourth level of geometric thinking there was only one student, or 9.1% of students without geometric difficulties, which was the case for the fifth level too. Results of the $\chi 2$ test showed a significant effect ($\chi 2\ (4) = 22{,}000$, $p < 0.01$) between students with geometric difficulties and the control group in the level of geometric thinking.

Table 5. Geometric level of thinking in students with and without geometric difficulties

	Geometric level of thinking					Total
	1st level	2nd level	3rd level	4th level	5th level	
Students without geometric difficulties	0	0	9	1	1	11
	0.0 %	0.0 %	81.8 %	9.1 %	9.1 %	100.0 %
Students with geometric difficulties	5	6	0	0	0	11
	45.5 %	54.5 %	0.0 %	0.0 %	0.0 %	100.0 %
Total	5	6	9	1	1	22
	22.7 %	27.3 %	40.9 %	4.5 %	4.5 %	100.0 %

DISCUSSION

The main goal of this study was to determine the prevalence of children with difficulties in one mathematical domain: geometry, to analyze the level of geometric thinking as an additional factor for classifying geometric difficulties and for better understanding problems and to investigate deficits in visual-spatial skills as a potential risk factor for developing geometric difficulties.

Results showed that 7.2% of elementary school students, 9 to 11 years old, have geometric difficulties. In the literature we can find information about the incidence for dyscalculia in general but there is no information about the percentage of students who have geometric difficulties only. The DSM-5 (American Psychiatric Association, 2013) estimates the prevalence rate of 3–7% for deficits in mathematics. Morsanyi, Bers, McCormack and McGourty (2018) used the DSM-5 diagnostic criteria to identify children with a potential diagnosis of specific learning disorder in mathematics (SLDM or developmental dyscalculia) and found prevalence of 5.7%. But DSM-5 diagnostic criteria includes substantial and quantifiable difficulties in learning and using mathematics skills without specifying geometry skills, just stating the arithmetic skills. Wadlington and

Wadlington (2008) noted incidence up to 8% for learning difficulty in mathematics, similar to this research, but also without including geometric skills.

There is increasing evidence showing that students with mathematical difficulties have problems with learning geometry due to visual-spatial deficits (Mistretta, 2000). Results of this study showed that students with geometric difficulties had problem with solving BST, a task which is very easy, and includes the ability of visual-spatial perception of the shape independent of the color. They also had problems to decide which of two lines is longer on the line judgment task. These were unexpected results if we consider that almost half of the students with geometric difficulties were on the first visualization level, and obviously had problems to recognize correct geometric shape and problems to determine the length. They also had problems with solving the Clock test which indicate problems with sustained visual attention, which could be connected with proper solving all other tasks. Many geometry skills depend on spatially representing mathematical relations, and students who struggle in mathematics frequently misunderstand spatial information (Geary, 2003).

Visual working memory supports many mathematical competencies, including geometry (Geary, 1996; Jeung, Chandler, & Sweller, 1997). Visual working memory has not been researched as frequently as verbal working memory in children with mathematics difficulties (Zhang, Ding, Stegall & Mo, 2012). In this study three tasks that measure visual memory were used. Children with geometric difficulties had problems in speed or accuracy during solving these tasks. They were also good predictors of geometric skills. This is in line with previous studies about the connection between geometry and visual-spatial working memory which showed that visual-spatial working memory directly predicts academic success in geometry (Giofrè, Mammarella, & Cornoldi, 2013; Giofrè, Mammarella, Ronconi & Cornoldi, 2013).

According to Hoffer (1981) there are five fundamental skills for mastering geometry: visual, verbal, drawing skills, logical skills, and applied skills. There is evidence showing that students with geometric difficulties have difficulties representing visual shapes (Triadafillidis, 1995), which was noted in this study too. Most students with geometric difficulties were on the second level, they saw figures as a set of properties, and learnt terms to describe them, but they cannot make connection between them.

Existing research rarely has addressed three-dimensional geometric properties and visual spatial imagery, although students are frequently less proficient with three-dimensional geometric shapes than they are with two-dimensional shapes (NRC, 2001), therefore we used tasks with three-dimensional geometric shapes. Students with geometric difficulties differ from their peers in the ability to mentally rotate one figure to compare it with another, to decide whether or not two objects they see are identical. Correct answers on this task was a good predictor of geometric ability. Duranovic, Dedeic and Gavric (2015) found that children with dyslexia performed equivalently to

those without dyslexia on the mental rotations test (Vandenberg & Kuse 1978), non-analytical spatial visualization task. Obviously, children with specific learning difficulties have different development of their spatial visualisation skills. While one group do not have problem with ability to mentally rotate objects and this ability can be used to encourage other problematic skills, the other group have problems and should work directly on development of these skills.

According to van Hiele's theory of geometry mental development levels (van Hiele, 1959), recognition or visualization is the first and most fundamental developmental step for children to learn geometry skills and concepts. Results of the study showed that more than half of the children with geometric difficulties did not have problem with this step, because they are on the second level, which gives us a positive view and the hope they can build these skills. Building on visualization and representation, children develop further levels of geometric reasoning, including analysis (e.g., thinking in terms of properties of visual figures), informal deductive (i.e., noticing relationships within and between figures), formal deduction (i.e., geometry proofs), and rigor (i.e., thinking in terms of abstract mathematical systems) (Gal & Linchevski, 2010).

Geometry skills at level 3 (abstraction/informal deduction) mean that the students master geometry skills at level 2 (analysis) and level 1 (visualisation) (Astuti, Suryadi, & Turmudi, 2018). Most students without geometric difficulties (81.8 %) were on the third level of geometry mental development, and 9.1% of them were on the fourth and on the fifth level. In the study conducted by Astuti, Suryadi, and Turmudi (2018) 23.7% students were at the level 1 (visualization), 44.7% at the level 2 (analysis), and 31.6% were categorized as level 3 (informal deduction). De Villiers and Njisane (1987) noted that 45 % students were at the level 2 or lower. Similar low levels in students in high schools were found by Malan (1986) and Smith and De Villiers (1989). All these results are worse than the results obtained in this study, which can be explained with the fact that they included all students, without making a distinction between students with geometric difficulties or not. Given that 23.7% of students were at the level 1 in the first study, and 45 % students were at the level 2 or lower, there is a real possibility that among examined students there were students with geometric difficulties.

It is important to know the geometry mental development levels of student. Before teaching students for a higher level, it is necessary to examine at what level they are. If a student gets a task that is at a higher level than the student's competencies, the communication will be poor. Such a procedure will create a problem for the students, they will be forced just to memorize and thus only achieve temporary and superficial success (Čižmešija et al., 2010). Once it has been determined to which Van Hiele level the students belong, certain activities can be done with them according to the child's level (Karjaković, 2014).

This study showed a large percentage of children with geometric difficulties in elementary schools. Different research has shown that many of these mathematical difficulties may be connected to problems in the visuospatial domain (Heathcote, 1994; Cornoldietal, 1999; Mammarella et al., 2006, 2010). This study showed problems in this aspect for children with geometric difficulties. Future research should include all children with mathematical difficulties and examining the relationship between deficits in different domains (i.e., deficits in arithmetic and deficits in geometry) in order to better understand their differences and similarities, and to analyze whether children experiencing a deficit in one domain show deficits in the other domain as well. Although comorbidity rates between disorders in these two domains are supposed to be high, it would be significant to determine whether deficits in specific domains also occur individually and do they have different causes and therefore require different interventions.

Prevention and early intervention are acknowledged as key components for reducing the impact of any potentially problems in child development (Shonkoff & Meisels, 1990). Another direction for future research could be building interventions based on risk factors to geometrical difficulties, which would enable the implementation of activities before problems worsen or by preventing their onset (see Marmot et al., 2008).

Although this study has gaven important insights into the geometrical difficulties some limitations should be considered for future research. The small sample size is one of limitations which restricted the possibility of generalizing the results. Future studies would need to examine a much larger sample to represent a large student population. Children from third to fifth grade were included in a sample. It will be important to future studies to investigate developmental mechanisms of geometric difficulties longitudinally, starting with younger age groups and including adults.

REFERENCES

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: American Psychiatric Association.

Astuti, R., Suryadi, D., & Turmudi, T. (2018). Analysis on geometry skills of junior high school students on the concept congruence based on Van Hiele's geometric thinking level. *Journal of Physics Conference Series, 1132*(1), 012036.

Attneave, F., & Arnoult, M. D. (1956). The quantitative study of shape and pattern perception. *Psychological Bulletin, 53*(6), 452–471.

Baddeley, A. D. (2000). The episodic buffer: a new component of working memory? *Trends in Cognitive Sciences, 4*(11), 417–423.

Badian, N. A. (1983). Arithmetic and nonverbal learning. In H.R., Myklebust (ed) *Progress in Learning Disabilities, Vol 5* (pp 235-264). New York: Grune and Stratton.

Badian, N. A. (1999). Persistent arithmetic, reading, or arithmetic and reading disability. *Annals of Dyslexia, 49*, 45–70.

Battista, M. T. (2002). Learning geometry in a dynamic computer environment. *Teaching Children*

Mathematics, 8(6), 333–339.
Bilbija, D., Milanković, J., & Runjić, N. (2009). *Teorija van Hiele-ovih o razumijevanju geometrije (Van Hiele's theory of understanding geometry).* Banja Luka: Faculty of Science.
Bull, R., Johnston, R. S., & Roy, J. A. (1999). Exploring the roles of the visual-spatial sketch pad and central executive in children's arithmetical skills: Views from cognition and developmental neuropsychology. *Developmental Neuropsychology, 15*, 421-442.
Burger, W. R., & Shaughnessy, J. M. (1986). Characterizing the van Hiele levels of development in geometry. *Journal for Research in Mathematics Education, 17*(1), 31-48.
Butterworth, B., Varma, S., & Laurillard, D. (2011). Dyscalculia: From brain to education. Science*, 332*(6033), 1049–1053.
Bynner, J., & Parsons, S. (2006). *Does Numeracy Matter More? National Research and Development Centre for Adult Literacy and Numeracy.* London: The Basic Skills Agency. Retrieved from http://www.nrdc.org.uk
Cai, D., Li, Q. W., & Deng, C. P. (2013). Cognitive processing characteristics of 6th to 8th grade Chinese students with mathematics learning disability: relationships among working memory, pass processes, and processing speed. *Learning and Individual Differences, 27*, 120–127.
Cass, M., Cates, D., Smith, M., & Jackson, C. (2003). Effects of manipulative instruction on solving area and perimeter problems by students with learning disabilities. *Learning Disabilities Research & Practice, 18,* 112–120.
Chew, C. M., & Lim, C. S. (2013). Enhancing primary pupils' geometric thinking through phase-based instruction using the Geometer's Sketchpad. *Asia Pacific Journal of Educators and Education, 28*, 33-51.
Clements, D. H., & Battista, M. T. (1992). Geometry and spatial reasoning. In D. A., Grouws (Ed.), *Handbook of Research on Mathematics Teaching and Learning* (pp. 420–464). New York: MacMillan.
Collin, C. A., & McMullen, P. A. (2002). Using MATLAB to generate families of similar Attneave shapes. *Behavior Research Methods, 34*(1), 55-68.
Cornoldi, C., Rigoni, F., Tressoldi, P. E., & Vio, C. (1999). Imagery deficits in nonverbal learning disabilities. *Journal of Learning Disability, 32*, 48–57.
Crnjac, D. (2013). *Teorije učenja matematike (Theories of learning mathematics).* Graduation thesis. Osijek: University of J.J. Strossmayera.
Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior, 19*(4), 450–466.
Dehaene, S., & Cohen, L. (1997). Cerebral Pathways for Calculation: Double Dissociation between Rote Verbal and Quantitative Knowledge of Arithmetic. *Cortex, 33*(2), 219–250.
Dehaene, S., Spelke, E., Pinel, P., Stanescu, R., & Tsivkin, S. (1999). Sources of mathematical thinking: Behavioral and brain imaging evidence. *Science, 284*, 970–974.
De Villiers, M. D. (2008). Uloga i funkcija dokaza u matematici (The role and function of proofs in mathematics). *Poučak, 35*, 13-17.
De Villiers, M. D., & Njisane, R. M. (1987). The Development of Geometric Thinking among Black High School Pupils in KwaZulu. *Proceedings of the Eleventh PME-conference. Montreal: 3*, 117-123.
De Risi, V. (2015). *Mathematizing Space: The Objects of Geometry from Antiquity to the Early Modern Age.* Switzerland: Springer International Publishing.
D'Amico, A., & Guarnera, M. (2005). Exploring working memory in children with low arithmetical achievement. *Learning and Individual Differences, 15,* 189–202.

Duranovic, M., Dedeic, M., & Gavric, M. (2015). Dyslexia and Visual-Spatial Talents. *Current Psychology, 34*(2), 207-222.

Ekstrom, R. B., French, J. W., Harman, H. H., & Dermen, D. (1976). *Kit of factor referenced cognitive tests.* Princeton: Educational Testing Service.

Fuys, D., Geddes, D., & Tischler. R. (1988). *The van Hiele model of thinking in geometry among adolescents. JRME Monograph No. 3*, Washington, D.C.: National Council of Teachers of Mathematics.

Gal, H., & Linchevski, L. (2010). To see or not to see: Analyzing difficulties in geometry from the perspective of visual perception. *Educational Studies in Mathematics, 74*(2), 163–183.

Geary, D. C. (1993). Mathematical disabilities: cognitive, neuropsychological, and genetic components. *Psychological Bulletin, 114*, 345–362.

Geary, D. C. (1996). Sexual selection and sex differences in mathematical abilities. *Behavioral and Brain Sciences, 19*, 229–284.

Geary, D. C., & Hoard, M. K. (2001). Numerical and arithmetical deficits in learning-disabled children: Relation to dyscalculia and dyslexia. *Aphasiology, 15*(7), 635–647.

Geary, D. C. (2003). Learning disabilities in arithmetic: Problem solving differences and cognitive deficits. In H. L. Swanson, K. Harris, & S. Graham (Eds.), *Handbook of learning disabilities* (pp. 199–212). New York, NY: Guilford Press.

Geary, D. C. (2004). Mathematics and learning disabilities. *Journal of Learning Disabilities, 37*, 4–15.

Giofrè, D., Mammarella, I. C., & Cornoldi, C. (2013). The structure of working memory and how it relates to intelligence in children. *Intelligence, 41*(5), 396–406.

Giofrè, D., Mammarella, I. C., Ronconi, L. & Cornoldi, C. (2013). Visuospatial working memory in intuitive geometry, and in academic achievement in geometry. *Learning and Individual Differences, 23*, 114–122.

Gross-Tsur, V., Manor, O., & Shalev, R. S. (1996). Developmental dyscalculia: Prevalence and demographic features. *Developmental Medicine and Child Neurology, 38*(1), 25–33.

Hammill, D. D. (1990). On defining learning disabilities: an emerging consensus. *Journal of Learning Disabilities, 23*, 76-84.

Heathcote, D. (1994). The role of visuo-spatial working memory in the mental addition of multi-digit addends. *Cahiers De Psychologie Cognitive-current Psychology of Cognition, 13*, 207–245.

Hoffer, A. (1981). Geometry is more than proof. *Mathematics Teacher, 74*, 11-18.

Jeung, H., Chandler, P., & Sweller, J. (1997). The role of visual indicators in dual sensory mode instruction. *Educational Psychology, 17*, 329–343.

Karagiannakis, G., Baccaglini-Frank, A., & Papadatos, Y. (2014). Mathematical learning difficulties subtypes classification. *Frontiers in Human Neuroscience, 8*(57), 1-5.

Kessels, R. P. C., van Zandvoort, M. J. E., Postma, A., Kappelle, L. J., & de Haan, E. H. F. (2000). The Corsi Block-Tapping Task: Standardization and Normative Data. *Applied Neuropsychology, 7*(4), 252–258.

Kinach, B. M. (2012). Fostering Spatial vs. Metric Understanding in Geometry. *Mathematics Teacher, 105*(7), 534–540.

Kosc, L. (1974). Developmental dyscalculia. *Journal of Learning Disabilities, 7*, 46-59.

Kroesbergen, E., & Van Luit, J. (2003). Mathematics interventions for children with special educational needs. *Remedial and Special Education, 24*, 97–114.

Lewis, C., Hitch, G. J., & Walker, P. (1994). The prevalence of specific arithmetic difficulties and specific reading difficulties in 9- to 10-year old boys and girls. *Journal of Child Psychology and Psychiatry, 35,* 283-292.

Luck S. J., & Vogel E. K. (1997). The capacity of visual working memory for features and conjunctions. *Nature, 390*, 279–281.

Maccini, P., Mulcahy, C., & Wilson, M. (2007). A follow-up of mathematics interventions for secondary students with learning disabilities. *Learning Disabilities Research & Practice, 22*, 58–74.

Mackworth, N. H. (1948). The breakdown of vigilance during prolonged visual search. *Quarterly Journal of Experimental Psychology, 1*, 6-21.

Malan, F. R. P. (1986). *Teaching strategies for the transition of partition thinking to hierarchical thinking in the classification of quadrilaterals*. Stellenbosch: University of Stellenbosch, Research Unit of Mathematics Education.

Mammarella, I. C., Cornoldi, C., Pazzaglia, F., Toso, C., Grimoldi, M., & Vio, C. (2006). Evidence for a double dissociation between spatial-simultaneous and spatial-sequential working memory in visuospatial (nonverbal) learning disabled children. *Brain Cognition, 62*, 58–67.

Mammarella, I. C., Lucangeli, D., & Cornoldi, C. (2010). Spatial working memory and arithmetic deficits in children with nonverbal learning difficulties. *Journal of Learning Disability, 43*, 455 –468.

Marmot, M., Friel, S., Bell, R., Houweling, T. A., Taylor, S., Health, CoSDo. (2008). Closing the gap in a generation: health equity through action on the social determinants of health. *Lancet,* 372, 9650, 1661–9.

Mazzocco, M. M., Feigenson, L., & Halberda, J. (2011). Impaired acuity of the approximate number system underlies mathematical learning disability (dyscalculia). *Child Development, 82*(4), 1224–1237.

McCloskey, M. (1992). Cognitive mechanisms in numerical processing: Evidence from acquired dyscalculia. *Cognition, 44*(1), 107–157.

McLean, J. F., & Hitch, G. J. (1999). Working memory impairments in children with specific arithmetic learning difficulties. *Journal of Experimental Child Psychology, 74*, 240–260.

Mistretta, R. (2000). Enhancing geometric reasoning. *Adolescence, 35*, 369–379.

Morsanyi, K., van Bers, B. M. C. W., McCormack, T., & McGourty, J. (2018). The prevalence of specific learning disorder in mathematics and comorbidity with other developmental disorders in primary school-age children. *British Journal of Psychology, 109*(4), 917-940.

Mueller, S. T. (2010). A partial implementation of the BICA Cognitive Decathlon using the Psychology Experiment Building Language (PEBL). International *Journal of Machine Consciousness, 2*, 273–288.

Mueller, S. T. & Esposito, A. G. (2014). Computerized Testing Software for Assessing Interference Suppression in Children and Adults: The Bivalent Shape Task (BST). Journal *of Open Research Software, 2*(1), e3.

Mueller, S. T. & Piper, B. J. (2014). The psychology experiment building language (PEBL) and PEBL test battery. *Journal of Neuroscience Methods, 222*, 250-259.

National Council of Teachers of Mathematics. (NCTM). (2000). Principles *and standards for school mathematics*. Reston, VA: Author.

National Mathematics Advisory Panel. (2008). *Foundation for success: The final report of the National Mathematics Advisory Panel.* Washington, DC: U.S. Department of Education.

National Research Council (NRC). (2001). Adding it up: Helping children learn mathematics. In J. Kilpatrick, J. Swafford, & B. Findell, (Eds.), *Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education*. Washington, DC: National Academy Press.

Ovčar, S. (1990). *Razvoj mišljenja u nastavi matematike (Development of thinking in teaching of*

mathematics). Čakovec: Zrinski.
Passolunghi, M. C., & Pazzaglia, F. (2004). Individual differences in memory updating in relation to arithmetic problem solving. *Learning and Individual Differences, 14*(4), 219–230.
Pedemonte, B., Watson, C., Borghesani, V., Ebbert, M., Allen, I. E., Pinheiro-Chagas, P., De Leon, J., Miller, Z. , Tee, B. L., & Gorno-Tempini, M. L. (2022). A novel approach to subtypes of developmental dyscalculia. *Research Square*. Retrieved: file:///C:/Users/KorisnikPC5/Downloads/A_novel_approach_to_subtypes_of_developmental_dysc-1.pdf
Raven, M. S. (1956). *Uputstvo za korišćenje Progresivnih matrica u boji (Instructions for the use of colored progressive matrices)*. Beograd: Centar za primenjenu psihologiju.
Razel, M., & Eylon, B. S. (1991). *Developing mathematics readiness in young children with the Agam Program*. Proceedings of the Fifteenth Conference of the International Group for the Psychology of Mathematics Education. Genova, Italy.
Rourke, B. P., & Conway, J. A. (1997). Disabilities of arithmetic and mathematical reasoning: perspectives from neurology and neuropsychology. *Journal of Learning Disabilities, 30*, 34–46.
Rubinsten, O., & Henik, A. (2009). Developmental Dyscalculia: Heterogeneity might not mean different mechanisms. *Trends in Cognitive Sciences, 13*(2), 92–99.
Shalev, R. S., Auerbach, J., Manor, O., & Gross-Tsur, V. (2000). Developmental dyscalculia: prevalence and prognosis. *European Child & Adolescent Psychiatry, 2*, II58-64.
Shalev, R. S. (2007). Prevalence of developmental dyscalculia. In D. B. Berch & M. M. M. Mazzocco (Eds.), *Why is math so hard for some children? The nature and origins of mathematical learning difficulties and disabilities* (p. 49–60). US: Paul H. Brookes Publishing Co.
Shepard, R. N. & Metzler, J. (1971). Mental rotation of three-dimensional objects. *Science, 171*, 701 –703.
Shonkoff, J. P. & Meisels, S. J. (1990). Early childhood intervention: The evolution of a concept. In: S. J., Meisels, & J. P., Shonkoff, eds. *Handbook of early childhood intervention*. New York: Cambridge University Press; p. 3–31.
Simic, N., Khan, S., & Rovet, J. (2013). Visuospatial, visuoperceptual, and visuoconstructive abilities in congenital hypothyroidism. *Journal of the International Neuropsychological Society, 19* (10), 1119–1127.
Smith, E., & De Villiers, M. (1989). *A comparative study of two Van Hiele testing instruments*. Poster presented at the 13International Conference of PME, Paris.
Šutalo, Ž. (2016). *Ključne ideje u podučavanju matematike (Key ideas in teaching of mathematics).* Graduation thesis. Osijek: University of J. J. Strossmayera.
Triadafillidis, T. A. (1995). Circumventing visual limitations in teaching the geometry of shapes. *Educational Studies in Mathematics, 2*9(3), 225–235.
Usiskin, Z. P. (1982). *Van Hiele levels and achievement in secondary school geometry*. Chicago, IL: University of Chicago, Department of Education.
Vandenberg, S. G., & Kuse, A. R. (1978). Mental rotations, a group test of three-dimensional spatial visualization. *Perceptual and Motor Skills, 47*, 599–601.
Van Hiele, P. (1959). *The child's thought and geometry*. Brooklyn: City University of New York.
Van Hiele, P. (1986). *Structure and insight: A theory of mathematics education*. Orlando, FL: Academic Press.
Venneri, A., Cornoldi, C., & Garuti, M. (2003). Arithmetic difficulties in children with visuospatial learning disability (VLD). *Child Neuropsychology, 9*, 175–183.
Volenec, V. (1979). Geometrija: Tehnička enciklopedija (Geometry: Technical Encyclopedia). Zagreb: Leksikografski zavod Miroslav Krleža.

Von Aster, M. G., & Shalev, R. S. (2007). Number development and developmental dyscalculia. *Developmental Medicine & Child Neurology, 49*(11), 868–873.

Zhang, D., Ding, Y., Stegall, J., & Mo, L. (2012). The Effect of Visual-Chunking-Representation Accommodation on Geometry Testing for Students with Math Disabilities. *Learning Disabilities Research & Practice, 27*(4), 167–177.

Wadlington, E., Wadlington, P. (2008). Helping students with mathematical difficulties to succeed. *Preventing School Failures, 53*(1), 2-7.

Wong, W. -K., Hsu, S. -C., Wu, S. -H., Lee, C. -W., & Hsu, W. -L. (2007). LIMG: Learner-initiating instruction model based on cognitive knowledge for geometry word problem comprehension. *Computers & Education, 48*, 582–601.

Asia Pacific Journal of Developmental Differences
Vol. 10, No. 1, January 2023, pp. 27—63
DOI: 10.3850/S2345734123000274

The experiences of Primary 6 students with dyslexia using the metacognitive-based approach of problem solving for algebraic word problems

Aishah Abdullah[1*]

1. *Dyslexia Association of Singapore*

Abstract

Research has shown that students with dyslexia internationally can struggle with aspects of Mathematics. Moreover, they specifically struggle with word problems, because of the mathematical language and multi-steps involved, and the demands on working memory. At the Dyslexia Association of Singapore (DAS), the Problem Sums for Upper Primary (PSUP) curriculum was developed in 2016 to meet the needs of our primary school students who were firm in their understanding of basic mathematical concepts but lacked the appropriate strategies to solve higher-order word problems. The PSUP curriculum utilizes a combination of Polya's 4-step processes, the Concrete-Representational-Abstract approach (C-R-A) and the Try-Share-Learn-Apply approach as its primary teaching methodology. As the programme has yet to explore students' meta-cognitive abilities in planning, monitoring, solving and checking word problems, this study aims to understand the thought processes of eight Primary six students in solving word problems involving Algebra concepts through interviews and a series of tests. To evaluate the effectiveness of the PSUP curriculum teaching approaches, the students' pre-test, review test and post-test scores were compared. The results showed that 75% of the students improved from Pre-test to Review test and from Pre-test to Post test for all the algebraic concepts taught. Students were given a questionnaire at the beginning and end of the intervention period to assess their confidence level in solving Mathematics problem sums. Responses from the questionnaires also showed that the students were more confident in solving word problems as compared to at the start of intervention. Limitations and instructional implications will also be discussed. Further research into the students' meta-cognition before and after solving word problems would give a deeper insight to how their thought processes may have evolved, and how the use of our structured metacognitive-based approach has an impact on them.

Keywords: Mathematical language and multi steps. Metacognitive-based approach. planning, monitoring, solving and checking word problems

* *Correspondence to:*
Aishah Abdullah (Albel), Lead Educational Therapist, Dyslexia Association of Singapore Email: albel@das.org.sg

INTRODUCTION

Dyslexia, Maths and Metacognition

Dyslexia is a specific learning difference that makes it difficult for people to read, write and spell (DAS, 2022b). Apart from English, the significance of maths in daily life is something that cannot be overstated, including for example, the ability to work out the discount for items they want to purchase. The development of the applications that we use and even aspects of engineering involve the use of mathematics at various levels. As such, it is important for students to be able to comprehend mathematical concepts and solve questions. In terms of mathematical word problem sums, metacognition is an important factor.

Relationship between Metacognition and Maths

Metacognition in essence is the awareness and understanding on one's own thought processes. Developing metacognition is important as it can improve an individual's ability to apply knowledge and skills in areas outside the context of which they were learned. This ability to transfer knowledge and skills across various areas of life is vital in general. Bringing the context back to mathematics, when working on word problem sums, students need to be aware of what they are doing, why they are doing it and be able to regulate these processes and adjust their plans if necessary.

How Dyslexia Impacts an Individual's Math Ability

However, Dyslexia could affect an individual's mathematical ability as well. There has been consistent evidence for difficulties with Mathematics in dyslexia, with a recent study comparing 193 adult dyslexics with controls showing that 62% had problems with subtraction with no evidence for difficulties in the controls (Reynolds and Carovalas, 2016). Students with dyslexia have certain inherent weaknesses which makes mathematics challenging for them, for example reversing numbers when writing. They may struggle with directionality as problems can be solved from right to left, top to bottom or even left to right, depending on the question. Weak working memory could lead to challenges in simple mathematical computations, for example, the ability of students to memorise the times tables (with 93% dyslexic adults impaired in tables in Reynolds and Carovalas, 2016). Even their execution of multi-step questions, which would require proper sequencing, can be impacted, as well, with students consistently losing their place and missing out stages in their working. Students may also face organisational and planning difficulties such as an inability to come up with a plan and strategize in order to determine a solution. Slower processing may lead to difficulties with abstracting information as well. Students with dyslexia could face difficulties with their language comprehension and reading skills as they may struggle to read the questions accurately and misunderstand the questions. Impulsivity and lack of inhibition,

associated with ADHD which is heavily co-morbid with dyslexia, may also lead to inability to check and reflect on their own thinking. For an overview of the difficulties encountered in Mathematics for children with dyslexia, see Chinn, (2015).

Evidence for the type of difficulty encountered, and the overlap between reading and Mathematics disabilities has been widely researched internationally. In 1999, Badian in the USA in a major study of over 1000 children found that 3.4% showed difficulties in both reading and Mathematics. In a series of family studies, Landerl and Moll, (2010) established that reading and Mathematics deficits were significantly transmitted together, with Joyner and Wagner (2019) showing that students with Mathematics disability had more than twice the incidence of Reading disability. Most recently, a high-risk family study from Snowling and colleagues in the UK (Snowling, Moll and Hulme, 2021) found that 60% of children with RD had MD as well. These findings clearly establish the importance of Mathematics support for many children with dyslexia.

In terms of learning Mathematics, both declarative (number facts) and procedural (algorithms for performing a calculation) are needed. These need to work in tandem in order to achieve success. On a theoretical level, both Procedural learning and the process of consolidation (the final stage in learning) have been shown to be impaired in children with dyslexia (Nicolson and Fawcett, 2007). More repetition is needed for students with dyslexia to firmly acquire concepts, and their skills are likely to remain more fragile under stress.

Moreover, these is a clear additive role here, for the impact of anxiety in Mathematics on dyslexic students' performance, with evidence for this from research internationally.

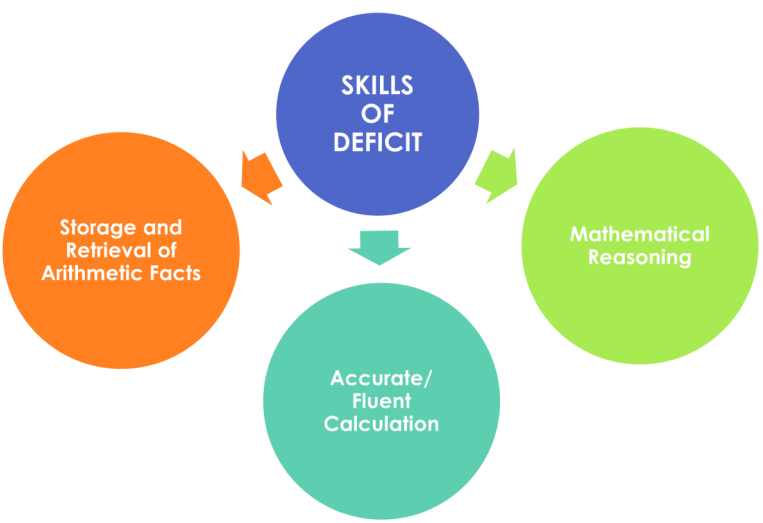


Figure 1. Learning Difficulties in Mathematics (DSM-5 diagnostic code 315.1)

Based on DSM-5 (Diagnostic Statistical Manual of Mental Disorders, 5th edition), dyslexia, which is now subsumed under the term "specific learning disorder" under diagnostic code 315.1., can be accompanied with an "impairment in mathematics".

Having such a diagnosis indicates that a child shows possible deficits in:

1. Number sense
2. Memorisation of arithmetic facts
3. Accurate or fluent calculation
4. Accurate math reasoning

The Role of Mathematics Anxiety in Dyslexia.

Interestingly, Mathematics anxiety is present even at the beginning of formal schooling (Maloney, 2012) and many of the techniques used to address this are based on addressing the phobias rather than the Mathematics itself. A systematic review (Mugnaini et al., 2009) has shown that dyslexia is a specific risk factor for anxiety and other internalising disorders. The stress associated with failure creates a vicious cycle of further failure. In a questionnaire study in 2008, Chinn demonstrated the role of the environment and personality as well as intellectual strengths or difficulties for dyslexia and Mathematics. Notably, secondary level dyslexic students tended to give no response answers based on their lack of confidence in Mathematics, with working memory issues exacerbating their difficulties.

As such, intervention in mathematics is important to help dyslexic students become more successful mathematics learners as well as build their confidence in their mathematical abilities. The topic on which this article focuses, problem solving, encapsulates many of the difficulties that dyslexic children experience in terms of metacognitive skills and strategy use. Problem solving demands the ability to read fluently, maintain the steps in working memory, follow the sequence through in the correct order, and deal with negatives or contradictory instructions, in order to reach the correct answer. For many dyslexic children, word problems highlight their difficulties in speed and accuracy, and thus they require a systematic approach with a formula that can help to build their metacognitive skills and reduce their anxiety in dealing with the word problems that can form the majority of the syllabus for this age group.

The Mathematics Curriculum and Problem Solving in Singapore

In Singapore problem solving has become central to the mathematics curriculum since 1992, (Lee 2008). More than 60% of the Mathematics curriculum for Primary schools constitutes solving word problems. Mathematical problem solving alludes to the importance of having students know how to form meaningful relationships from the given information in the word problem and to relate the relationships to the mathematical

operations (Van de Walle, 2004).

Word Problem sums generally require students to be able to accurately comprehend and organise the information provided, come up with a plan to solve, sequence the operations and steps used, and if the questions requires two or more steps, write number sentences, complete workings and adjust their plan if necessary. As such, being able to not only comprehend but solve word problem sums is vital for all students in general.

The inseparable link between assessment and curriculum points to the fact that word problems are a mainstay in the Singapore primary mathematics curriculum and has led many schools to teach problem solving by teaching word problems. The word problems include non-routine, open-ended and real world problems.

The development of Mathematical problem solving ability is dependent on five interrelated components, namely, concepts, skills, processes, attitudes and metacognition. Each time a new concept is introduced, problem solving becomes central.

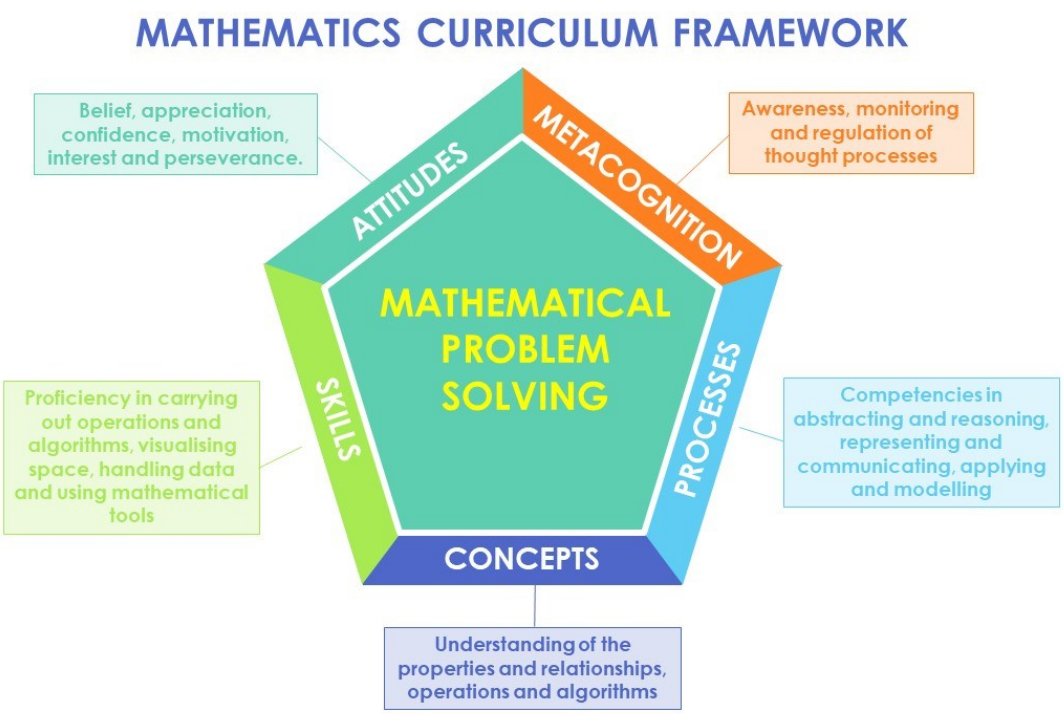


Figure 2. . Components of mathematical problem solving.

Mathematics Programmes at the Dyslexia Association of Singapore

The Mathematics Programme at the Dyslexia Association of Singapore has been designed to effectively support students with dyslexia who have persistent difficulties with mathematics. As students may have diverse mathematical ability, the program currently offers three main curricula; The Essential Maths Programme, Secondary 1 Normal Technical Programme and the Problem Sums for Upper Primary Programme also known as PSUP (DAS, 2022). In this article, the PSUP will be evaluated for effectiveness.

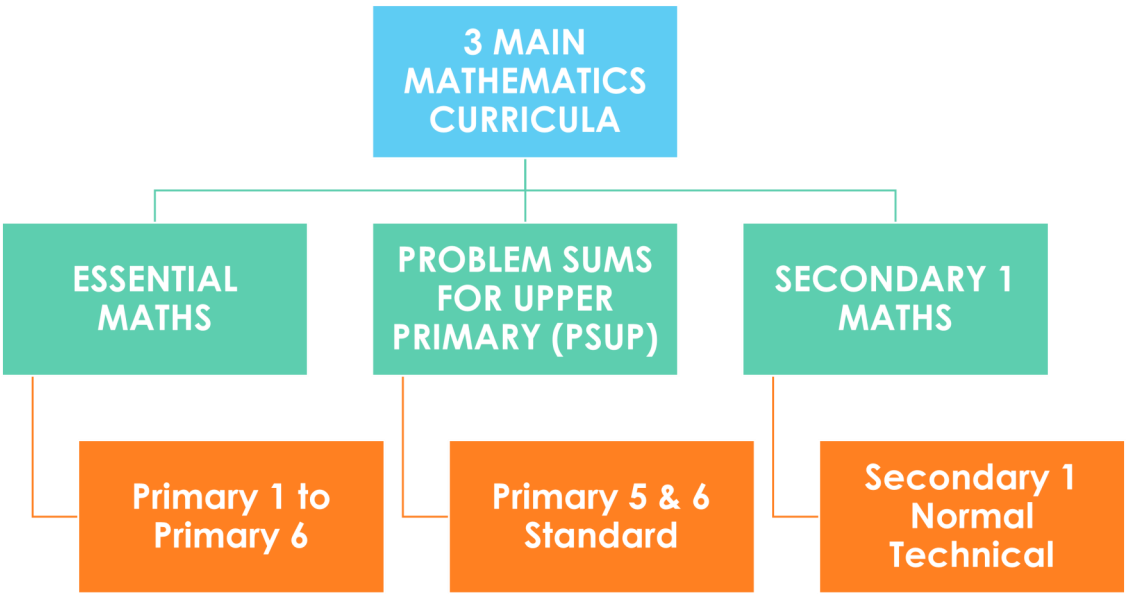


Figure 3. The Mathematics curricula at DAS, Singapore

Components of the Problem Sums for Upper Primary Programme (PSUP)

The Problem Sums for Upper Primary Programme was developed in 2016 to address the needs of students in Primary 5 and 6 Standard who were firm with their basic mathematical concepts but needed more support to understand and solve word problem sums. The programme focuses on teaching students to identify challenging word problem types in each topic as well as how to use reading comprehension skills and heuristic strategies to comprehend and solve those problems.

The programme as a whole utilizes various teaching approaches such as the Orton Gillingham Approach (where classes are language based, cognitive and diagnostic and prescriptive. Lessons are structured, cumulative and sequential as well as emotionally sound. Direct instructions are given to students as well.

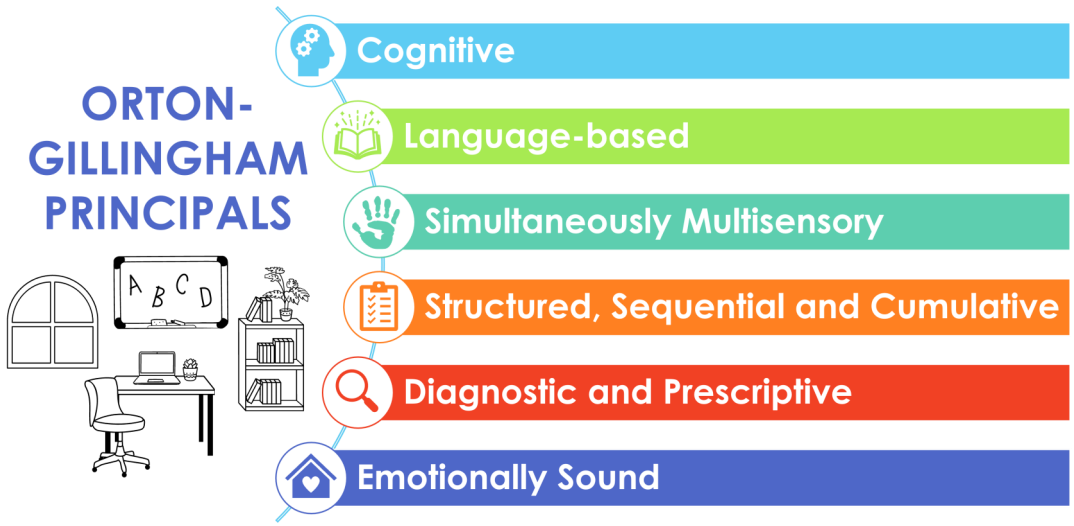


Figure 4. Orton Gillingham principles used in DAS

The Problem Sums for Upper Primary Programme utilizes a combination of other approaches such as Po'lya's 4 step processes to help student understand the problem, come up with a plan to solve the problem, solve the problem and check the solution.

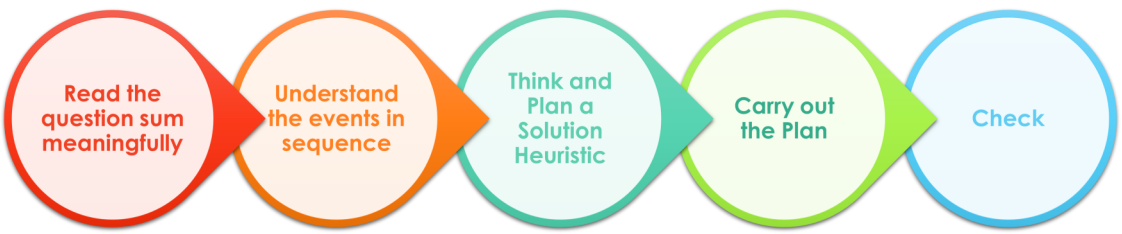


Figure 5. Po'lya's 4 step process (Po'lya, 1971)

To augment the teaching of problem solving, mathematics teachers in Singapore mainstream schools and at the Dyslexia Association of Singapore train students on Po'lya's (1971) approach towards problem solving (Ministry of Education, 2006).

Po'lya (1971) described mathematical problem solving as comprising four stages, namely, understanding, planning, carrying out the plan, and looking back. This model encourages students to first read and understand the problem, particularly identifying the information given and the information that needs to be found. Students then proceed to devise a plan by determining the methods, strategies or heuristics that are applicable and to decide on the most appropriate or effective approach. Subsequently, the model guides students to carry out their plan to solve the problem and to switch strategies if the planned approach did not work. Finally, the model prompts students to look back at their solution to determine if their answer is reasonable within the problem context, and that they have indeed solved the problem by finding what they are required to find. Students are also to reflect about the problem-solving process and determine which part of their solution worked and which did not so as to train themselves to predict the strategy that could be used to solve other similar problems in future.

Thus the problem-solving process is modelled in classroom lessons, and students are guided to successfully solve the word problems applying recommended heuristics introduced to them by their mathematics teachers.

In addition, in integrating problem solving in the classroom, the Mathematics teacher creates an environment in which students discover more than one approach to solve given problems. Such an environment is conducive in promoting learning for all students and supports students with different learning styles. This view is supported by Moser (1992) who reasons that "an orientation towards problem solving can accommodate individual differences, especially if the philosophy is adopted that there is more than one way to solve most problems.

The Concrete-Representational and Abstract approach

Students are given opportunities to use physical objects to experience the concept in real life, before the objects are represented using pictures so as to help students reduce their dependence on the physical manipulatives to solve the question. At the abstract stage, students can draw on their understanding of the problem as shown to them during the Concrete and Representational Stage to solve the questions.

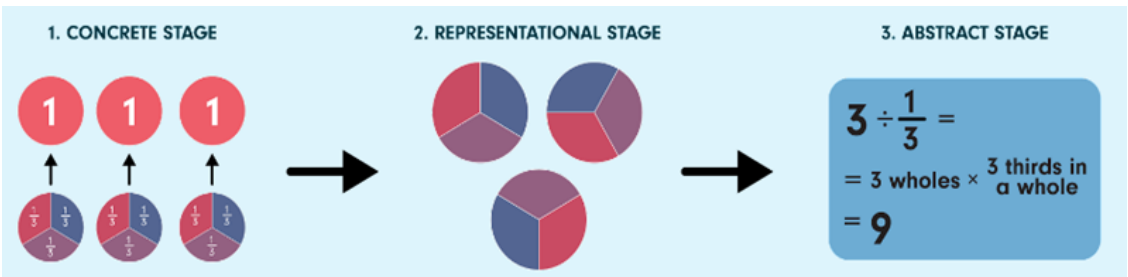


Figure 6. From concrete representational to abstract stages (DAS, 2022a)

Lastly, a try-share-learn-apply approach is used as well to help students walk through the problem-solving process in a collaborative and interactive setting.

Figure 7. Collaborative and interactive learning

To enable students to solve problems effectively, students need to be equipped with effective problem solving strategies so that they can apply them in problem solving. To achieve this end, a number of heuristics are explicitly introduced to the students when a new concept is introduced to them to enhance their problem solving performance.

METHODOLOGY

The type of research that was used in this case study is qualitative and quantitative in nature. Results of pre, mid-post (review) and post-tests of several mathematical topics were analyzed and students were given questionnaires before and after the intervention to express their confidence levels. They were also interviewed on the processes of their problem-solving skills and techniques used.

Participants

The mean ages of the children are indicated in the table below:

Table 1. Mean ages of children participating

	Girls	**Boys**
Mean Age	13.41	13.44
Range	12.91 - 13.78	12.96 – 14.02

The reason students are enrolled in the PSUP programme is to improve on their problem-solving skills by learning appropriate strategies for the different problem types. These students were in the Essential Mathematics Programme before coming on PSUP as they have shown the potential to take on higher order Mathematics.

A total of 8 primary six students- 4 boys and 4 girls, all 12 years of age participated in this case study. All the students had previously received a diagnosis of dyslexia from a psychologist and have learning difficulties in Language and also Mathematics. The students involved in the research were from two different centres and taught by two different teachers. Two students were from Centre (A) and were taught by Teacher A. The other six students were from Centre (B) and taught by Teacher B. All the eight students were taking P6 Standard Mathematics in their mainstream school. This means that they are firm in their understanding of their basic Mathematics concepts. Based on our in-house profiling assessment, the students are of average ability. Students in the Essential Mathematics Programme are mostly Average to Low support learners. Upon registering for the DAS Math programme, all students undergo an in-house profiling test, which the Maths Team has developed, based on their respective school levels and streams. The test evaluates number sense and the four operations of Whole numbers. Fractions are included only at the Primary 6 level. The profiling assessment results are analysed and students of similar ability are placed together to form classes based on their current Mathematics abilities and school level. 7/8 of the students on the Problem Solving for Upper Primary (PSUP) were recommended by their Mathematics Educational Therapists (Edt) while 1 student applied to join the PSUP programme.

Procedures

A case study was conducted over a period of 10 weeks in Term 1 2021 from Week 1 to Week 10. Ten concepts are covered in each term and each concept covers two hours.

Table 2. Concepts covered by the case study group in Term 1 2021

Week	Topic
1	Algebra
2	Simultaneous concept
3	Simultaneous concept
4	Division of Fractions
5	Equal concept involving ratio
6	Excess and Shortage
7	Penalty Charge
8	Ratio – Quantity and Value
9	Percentage – Increase and Decrease
10	Review & Post test (first hour); PSUP Research Student Interviews (2nd hour)

A key feature of the approach was the development of structured worksheets, that lead the students through the processes needed systematically, providing background information on the task, and a system for checking their progress. See appendix 3 – Student Worksheet structure

For the purpose of this research, Algebra and Simultaneous concepts were selected from the Primary 6 Mathematics syllabus. The topic of Algebra was chosen as it was new for the students and it required them to use letters to represent unknown quantities and express relationships, which are abstract for them.

The algebra concept is the first concept of the PSUP curriculum in Week 1 followed by the Simultaneous concept which is an extension of the Algebra concept in Week 2 of the term.

To start on the P6 PSUP curriculum, students first did a one question 5-minute pre-test on Algebra before they were formally introduced to the algebra concept. The recommended strategy for algebra concept is 'Draw a part-whole model' applying the PSUP in-house 'Try Share Learn Apply' approach. At first, at the Try stage, students worked out a question posed to them. At the Share stage, each student shared his/her solution strategy. Then at the Learn stage, Teachers introduced a recommended strategy. Students practiced the recommended strategy with about five questions and then brought back a question as homework practice. At the start of the next lesson in Week 2, students did a one question 5-minute review test to assess how well they understood the algebra concept. They then did a one question 5-minute pre-test on the Simultaneous concept before this concept was next introduced to them.

The recommended strategy for the Simultaneous concept is 'common multiples'. As the Simultaneous concept involved higher order thinking processes, two weeks were allowed for learning this concept. Each week, students practiced with about 2-3 questions and brought back a homework question for reinforcement practice at home. At the start of Week 4, students did a one question 5-minute review test to check their understanding of the Simultaneous concept.

Students undertook a questionnaire to express their confidence levels. They were also interviewed on the processes of their problem-solving skills and techniques used
The algebra concept is the first concept of the PSUP curriculum in Week 1 followed by the Simultaneous concept which is an extension of the Algebra concept in Week 2 of the term.

In the subsequent six weeks, the students learned the following concepts: division of fractions, equal concept involving ratio, excess and shortage, penalty charge, ratio - quantity and value and increase and decrease of percentage.

In the first hour of the 10th week lesson, the teacher reviewed all the eight concepts covered in the term (Table 1) with the students first before letting them do the termly post test on the eight learned concepts. In the second hour, students did a questionnaire (see Appendix 1) to measure their confidence level in doing the post test. An interview questionnaire (see Appendix 2) was also done to find out about their thought processes in learning the algebra and simultaneous concepts.

RESULTS AND FINDINGS

Performance of the participants was compared at pre, review and post-test and the results presented in the figure below.

Pre-test vs Review-test vs Post-tests scores

A comparison of student performance at pre-test, review and post-test is presented in the figures below.

Results for Algebra Concept:

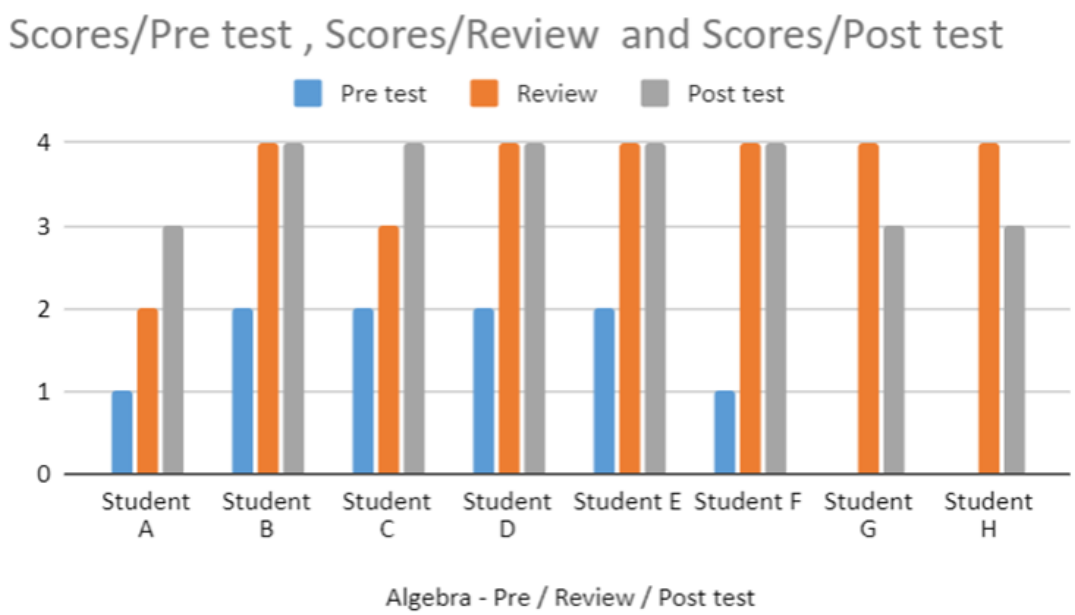


Figure 7. Bar chart of performance on Algebra concept

Each question in the Pre - test, Review test and Post-test carried a maximum of 4 marks.

Table 3. Students' performance at Pre - test (before teaching):

Total of	Obtained	Obtained	Obtained	Obtained	Obtained
Number of	2	2	4	0	0

In the Algebra pre- test, out of the 8 students who participated in the survey, 2 students obtained a zero score, 2 students obtained 1 mark and 4 students obtained 2 marks.

Table 4. Students' performance at Review test (immediate test after teaching):

Total of	Obtained	Obtained	Obtained	Obtained	Obtained
Number of	0	0	1	1	6

However, at the Review test on Algebra in the following week, 1 student obtained 2 marks, 1 other student obtained 3 marks while the majority (6 students) obtained the maximum 4 marks. On the whole, all 8 students demonstrated improved scores.

Table 5. Students' performance at Post-test (delayed test at end of term):

Total of	Obtained	Obtained	Obtained	Obtained	Obtained
Number of	0	0	0	3	5

At end of term Post-test, 3 students obtained 3 marks while the other 5 students obtained the maximum 4 marks.

Thus it was observed that students retained their learning of the algebra concept.

Results for Simultaneous concept

Simultaneous concept- Pre-test, Review test and Post test scores:

Similarly to the algebra concept, each question in the Pre - test, Review test and Post-test of the Simultaneous concept also carried a maximum of 4 marks.

Table 6. Students' performance at Pre - test (before teaching)

Total of	Obtained	Obtained	Obtained	Obtained	Obtained
Number of	3	2	2	1	0

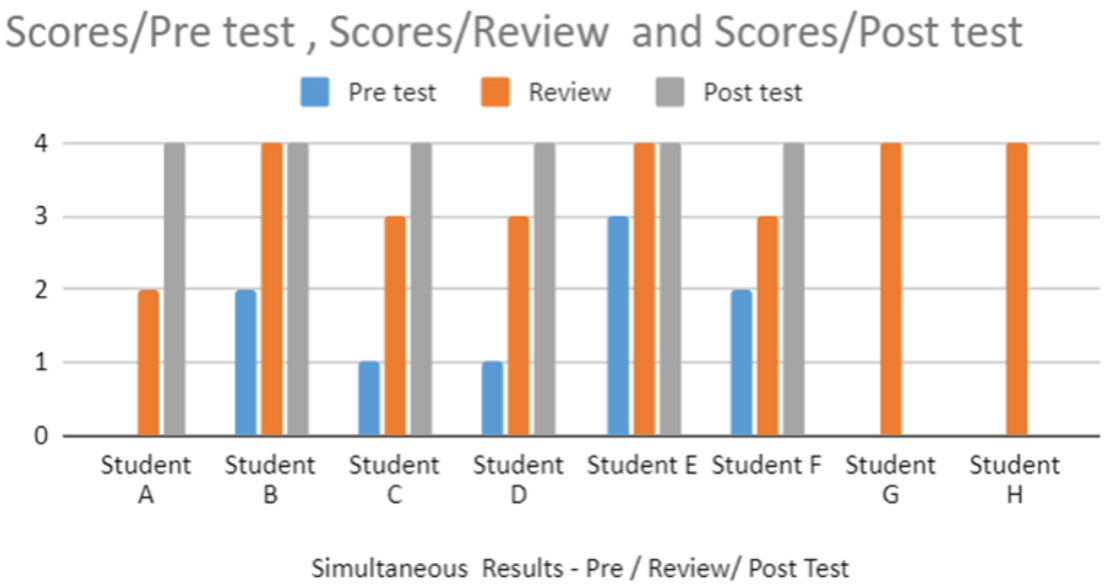


Figure 9. Bar chart of performance on Simultaneous concept

At the pre- test of the Simultaneous concept, out of the 8 students who participated in the survey, 3 students obtained a zero score, 2 students obtained 1 mark, another 2 students obtained 2 marks and only 1 student obtained 3 marks.

Table 7. Students' performance at Review test (immediate test after teaching):

Total of	Obtained	Obtained	Obtained	Obtained	Obtained
Number of	0	0	1	3	4

However, at the Review test on Simultaneous concept in the following week, 1 student obtained 2 marks, 1 other student obtained 3 marks while the other 4 students obtained the maximum 4 marks. On the whole, all 8 students demonstrated improved scores.

Table 8. Students' performance at Post-test (delayed test at end of term):

Total of	Obtained	Obtained	Obtained	Obtained	Obtained
Number of	2	0	0	0	6

At the end of the term Post-test, 2 students obtained zero marks while the other 6 students obtained the maximum 4 marks.

Thus, it was observed that 2 of the students who obtained the maximum 4 marks in the review test did not retain their learning of the simultaneous concept and so scored zero marks. They were from Centre (A).

Their reasons for the poor performance were:

- their teachers from mainstream school had not yet taught them the mathematics equations strategy to solve the genre of questions related to Simultaneous concept.
- The equations strategy was also not practiced in working out the solutions for sums in the topics that were taught after so the strategy was forgotten.
- In Centre B the teacher reinforced the equations strategy in the topic of Percentage increase / decrease concept that was taught in Wk 5.
- Although 3 of the students scored a zero in the pre-test, there may have been individual differences in their level of understanding that the pre-test was not sensitive enough to capture.

The results show that 75% of the students successfully understood and managed learning the simultaneous concept while the other 25% regressed in their scores and so need reteaching.

Using of Strategies Taught

In teaching the Algebra concept, the recommended strategy was drawing a part whole model to label and visualise the information from the given sum together with the equation statements.

In the review test on Algebra, the six students from Centre (B) applied the recommended strategy, while the two students from Centre (A) did not. However, at end of term Post

test all the students successfully applied the strategy. Table 9 shows the information.

The recommended strategy for teaching the Simultaneous Concept is the writing of Equations to transfer the information in the problem situation into meaningful mathematical equations:

e.g. 4s + 6y = 60 (Equation 1)
2s + 3y = 75 (Equation 2)

Table 9. Strategy use in Algebra

	ALGEBRA—PRE / REVIEW / POST TEST					
	Scores			**Recommended Strategy: Draw a part-whole model**		
	Pre Test	**Review**	**Post Test**	**Pre Test**	**Review**	**Post Test**
Student A	1	2	3		Y	Y
Student B	2	4	4		Y	Y
Student C	2	3	4		Y	Y
Student D	2	4	4		Y	Y
Student E	2	4	4		Y	Y
Student F	1	4	4		Y	Y
Student G	0	4	3		N	Y
Student H	0	4	3		N	Y

Legend

Y = Used the recommended strategy
N = Did not use strategy

Students needed to use the common multiples strategy to make one of the unknowns in the two equations common and then eliminate the common multiple in order to solve the sum.

Students' performance from the review and post test showed that only the 2 students from Centre A did not apply the strategy. The table below shows the findings:

Algebra concept - In the pre-test, Student E and Student F applied the model strategy to work out the solutions. The other students applied the unitary method as the solution. In the review test, students applied the recommended strategy- model drawing. However, in the post test students applied a combination of model drawing and unitary approach to solving the word problems.

Table 10. Strategy use in Simultaneous concept

	SIMULTANEOUS RESULTS—PRE / REVIEW / POST TEST					
	Scores			**Recommended Strategy: Common Multiples**		
	Pre Test	**Review**	**Post Test**	**Pre Test**	**Review**	**Post Test**
Student A	0	2	4		Y	Y
Student B	2	4	4		Y	Y
Student C	1	3	4		Y	Y
Student D	1	3	4		Y	Y
Student E	3	4	4		Y	Y
Student F	2	3	4		Y	Y
Student G	0	4	0		Y	N
Student H	0	4	0		Y	N

Legend

Y = Used the recommended strategy
N = Did not use strategy

Simultaneous concept - All the students worked out the solutions to the questions in the pre/review and post-tests by writing unitary equations relevant to the sums.

In the review test, students applied the strategy introduced to them. However, in the post

tests on Algebra and Simultaneous Concept, students applied a combination of both model and unitary approaches to solving the problems.

It is interesting to note that the students who used the unitary method of writing equations to arrive at the solution had already mentally mastered the concepts and wanted to document the workings in the shortest way. This is evident of their increased ability to understand, plan and solve effectively. Thus the success of the PSUP problem solving intervention processes.

Interview Questions on Students' working processes after the Post-test

Table 11. Interview responses

Interview Questions and Student Responses	
1.	**On a scale of 1 to 5, how easy was this test for you? 1 being very easy, 5 being very difficult.**
	3 students - 2; 3 students - 3; 1 student – 1; 1 student no response
2.	**Which question did you find the easiest?**
	Algebra concept Question
3.	**Which question did you find challenging?**
	Simultaneous concept Question
4.	**I would like you to explain to me in detail what went through your mind when you saw question 1 (Algebra Question)**
	When ate 2 means minus 2 then divide; Understand how to do
5.	**What strategies did you use to help you understand this problem?**
	Read meaningfully; Apply Polya processes
6	**Was the strategy you used helpful? If not, what did you do?**
	Yes; Think deeply
7.	**Can you tell me more about the sequence of steps you took to solve this question?**
	Work out the Maths equations following the events in the question
8.	**What happens after you carried out your steps? What did you do to check your work?**
	I double checked by putting the answer number into the question and worked out the sum; I check that the numbers and calculations are correct
9.	**How easy or difficult did you find this question? 1 being very easy, 5 being very difficult**
	5 students – 2; 2 students – 3; 1 student did not answer
10	**Let's move on to Question 2 (simultaneous equation). Can you describe to me in detail how you approached this question?**
	I had to read it multiple times to understand the question. Draw pictures to visualise the situations

Interview Questions and Student Responses (Cont')	
11	**What strategies did you use to help you understand this problem?**
	I read it repeatedly; I draw pictures to visualise and understand
12	**Was this strategy you used helpful? If not, what did you do?**
	Find how much 1 desk and 1 chair is; Find how much each cost then find the cost of 2 chairs.
13.	**Can you tell me more about the sequence of steps you used to solve this problem?**
	First, I find the cost of 1 chair. Then I can find the cost the desk.
14.	**What happens after you have carried out your steps?** **What did you do to check your work?**
	I used Work backwards strategy; I make sure that the numbers and calculations are correct.
15.	**How easy or difficult did you find this question?** **1 being very easy, 5 being very difficult**
	4 students – 3; 3 students – 5; 1 student - 2
16.	**Let's look at one of the questions you found challenging. Could you tell me why this question is challenging for you?**
	Difficult to understand the meaning
17.	**Can you describe how you approached this question?**
	Reread it meaningfully; Annotate – underline key words, draw boxes
18.	**At which point did you get stuck? What did you do then?**
	Reread it meaningfully; Draw a model; Move on to the nest question
19.	**You have attended our Problem Sums class for 1 term.** **How do you find the lessons?**
	I draw models, write equations, list the steps, draw pictures to solve the questions; The questions are helpful in examinations; Lessons are fun; Worksheets are good.
20.	**What are some strategies you have picked up from our lessons?**
	Underline keywords; Unitary method; Draw models and diagrams; Write Mathematics equations; Act out the events
21	**(a) How likely will you use these strategies in your school work?** **1- not at all, 5- I will definitely use them** **(b) Tell why you chose this score.**
	(a) 2 students – 3; 2 students – 5; 1 student – 2; 3 students did not answer (b) Useful; Will help in getting method mark
22	**What do you like about the PSUP lessons?**
	Helps to catch up in class (school). Don't understand in school; Interactive; I can have friends to help me learn.
23	**How can we improve our lessons for future batches of students?**
	Shorter questions

Observations of student responses about the post-test:

Students generally found PSUP lessons fun, interactive and useful. Students could apply the learnt strategies and heuristics with school examination question types.

Questionnaire on Student's Confidence Level in Mathematics

Question - How confident are you in Solving Mathematics Problem sums

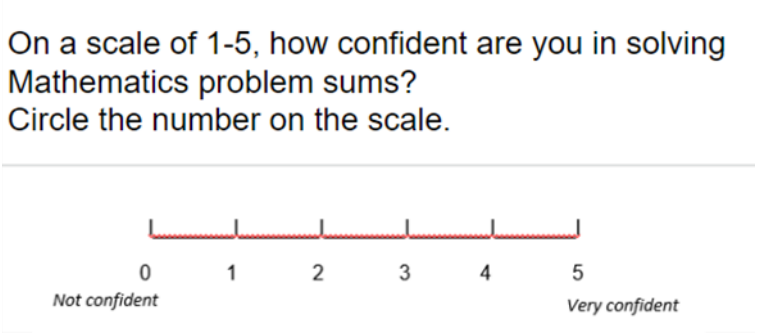


Table 12. Students Confidence level in Mathematics Pre and Post Test

Student	Pre-test responses on Confidence level	Post-test responses on Confidence level
Student A	3	4
Student B	3	4
Student C	1	3
Student D	2	3
Student E	2	4
Student F	4	4
Student G	3	2
Student H	1	2

*NB. Question 1 was omitted in the post-test as question 2 is more reflective of the confidence level. As such, Pre-test question 2 is compared with Post-test question 1.

Table 13. Summary of confidence level findings

Rating	Pre-test No of students	Post-test No of students
0	0	0
1	2	0
2	2	2
3	3	2
4	1	4

As the rating is on a scale of 1-5, the rating of 4 and 5 are considered as being confident. Thus, the results show that 1/8 – 12.5 % of the students felt confident solving problem sums at the pre - test level. However, at the Post test level 4/8 - 50% of the students felt confident. This is an increase of 37.5%.

Table 14. Strategies used when solving Mathematics problem sums

Strategy	No of student ticks	Strategy	No of student ticks
Working backwards	3	Assumption method	0
Listing	3	Before/ After	3
Draw a diagram	10	Unitary	9
Act it out	2	Simplify the problem	0
Guess and Check	3	Solve part of the problem	5
Look for a pattern	7		

Question: Which of these strategies do you use when solving Mathematics problem sums? Tick the strategy,

Observations: The common heuristics used by the students are: Draw a diagram, Unitary, Look for a pattern and Solve part of the problem

Frequency of use of strategies

Question: How often do you apply these POLYA processes for solving problems? Circle one of the following on the scale:

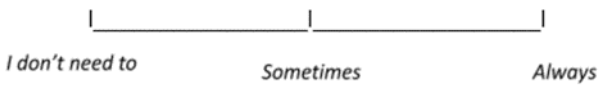


Table 15. Application of Polya Processes: Understand the Problem and Plan a Solution Strategy

Student	Understand the Problem		Plan a Solution Strategy	
	Pre-test	Post test	Pre-test	Post test
Student A	Sometimes	Always	Always	Always
Student B	Sometimes	Always	I don't need to	Always
Student C	Sometimes	Always	I don't need to	Always
Student D	Sometimes	I don't need to	Sometimes	Always
Student E	Sometimes	Always	Sometimes	Always
Student F	Always	Always	Always	Always
Student G	I don't need to	Always	Sometimes	Always
Student H	Always	Sometimes	I don't need to	Sometimes

Observations:

- 75% of the students find it necessary to understand the word problem before considering a suitable solution strategy.
- 87.5% of the students devise a strategy to solve the word problem.

Table 16. Application of Polya Processes: Solve the Problem and Check the solution

Student	Solve the Problem		Check the solution	
	Pre-test	**Post test**	**Pre-test**	**Post test**
Student A	Always	Always	Sometimes	Always
Student B	Sometimes	Always	Sometimes	Always
Student C	Always	Always	Sometimes	Sometimes
Student D	Sometimes	Always	Always	Always
Student E	Sometimes	Always	Sometimes	Sometimes
Student F	Always	Always	Sometimes	Sometimes
Student G	Always	Always	Always	I don't need to
Student H	Always	Sometimes	Sometimes	Sometimes

Observations:

- 87.5% of the students try their best to successfully solve the word problem.
- 37.5% of the students do their best to check their solutions. The remaining 62.5% do not consistently check their workings.

When these students were asked why they do not check their workings, they stated the following reasons:

In school, students do not need to use a checklist to check their workings and solutions. So they do not have the checking habit.

Students need to go on to other word problems and complete them quickly or else there will be some sums undone.

DISCUSSION

In this case study approach to evaluating the success of the PSUP programme at DAS, a series of significant results were found for the overall impact of the programme, and for components of the approach, which indicate that the PSUP is effective on many levels.

The post test scores for both the algebra and simultaneous concepts were greater between pre and post-tests and between review and post-tests. Thus, retention has taken place. The curriculum C-R-A, Try-Share-Learn-Apply and Polya's 4-step processes have definitely benefited the students in terms of their difficulties as students with dyslexia.

C-R-A

At the introductory stage, concrete resources were used for the students to visualize the concepts. This helped the students to be able to solve the word problems more readily. Students could also explore and use the resources to work on the other word problems should they need to act the situations presented in the word problems.

The Try-Share-Learn-Apply and Polya's steps

The Try stage enabled each student to work independently to solve the try problem. At the Share stage, each student had the opportunity to deep think and organise thinking processes to present the solution. The teacher and peers were thus able to listen, follow the presentation sequence and provide critical observations to help the student reflect and present the solution more effectively. Students were also able to pick up skills from each other. The Learn and Apply stages enabled the students to remember, retain and recall the learned solution/ strategy effectively.

Learn stage—Teaching Students to Read Word Problems Meaningfully

1. **Repeated Reading**
   - 1st reading: To get the main idea of the situations presented in the problem sums
   - 2nd reading: Read to make connections with the given information.
     - Subjects in the problem.
     - Their relationships.
     - What the question wants us to find

2. **Apply annotation**
   - Using symbols to highlight the important information.
     1. Use different colours to highlight different subjects
     2. Use different shapes to annotate different kinds of numbers
     3. Underline all mathematical terms
     4. Draw arrows to show the direction of comparison

The reading strategies helps students to organise their thinking and so document their mathematics equations and workings logically.

Good reading will lend itself into comprehension

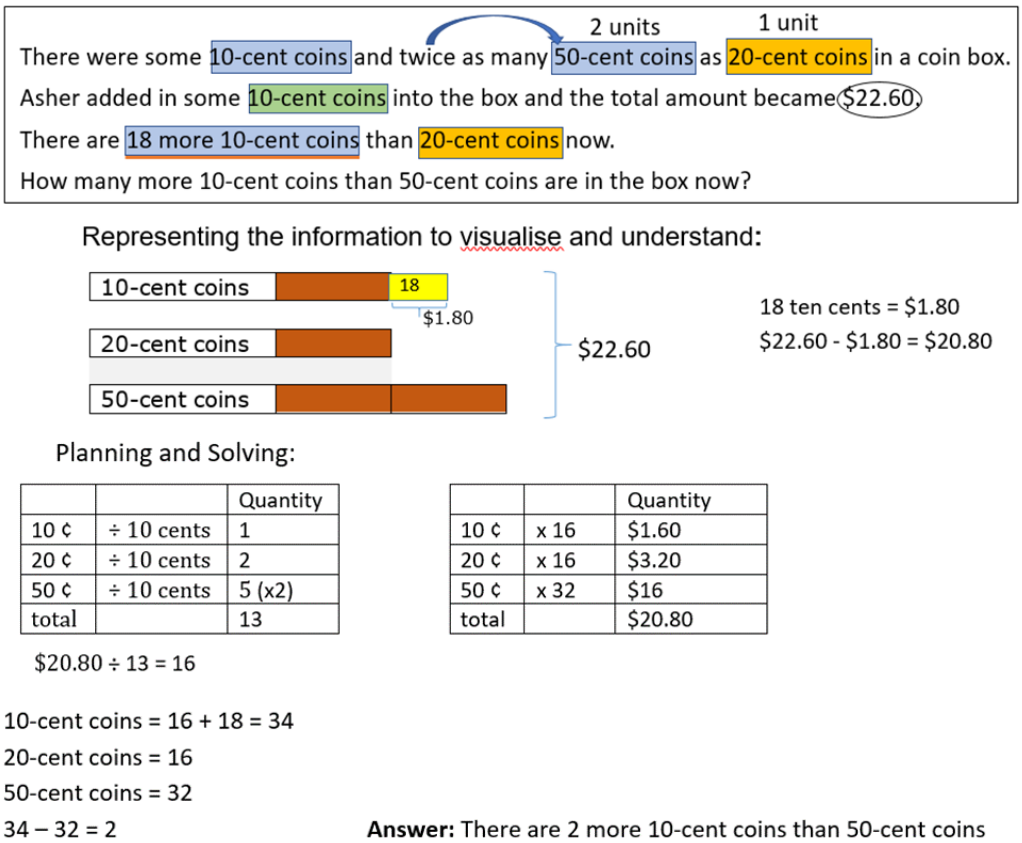


Figure 10. An example of a repeated single identity word problem—with annotation

3. Checking Written Solutions

As student worksheets have a checklist, Teachers can insist and check that when students submit their written work the relevant statements are ticked in the checklist at each lesson to ensure that checking becomes an automatic habit with the student. With regular practice it will not be cumbersome or cognitive overload for them.

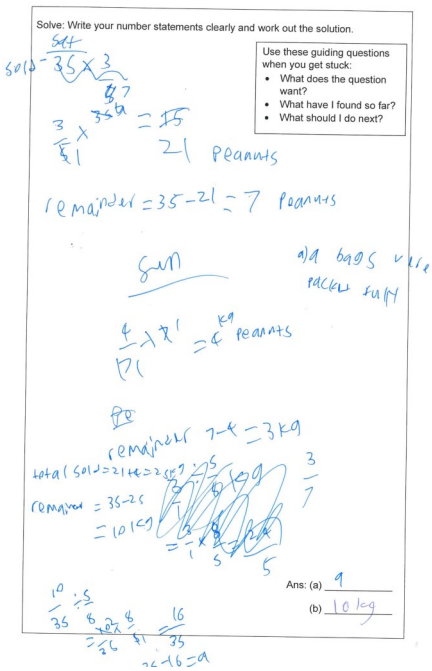
Table 17. Checklist in student's worksheet

PLEASE TICK (✓)	
	I have found what the question wants me to find
	My answers(s) make sense
	I have copied the numbers correctly from the question and my workings.
	My calculations are accurate
	I wrote the correct units on my answer

Observations how students wrote their workings before intervention and after intervention

A good point to note is that students wrote their workings more neatly and in logical sequence after intervention showing that they understood, planned and documented confidently.

Student working **before** intervention



Student working **after** intervention

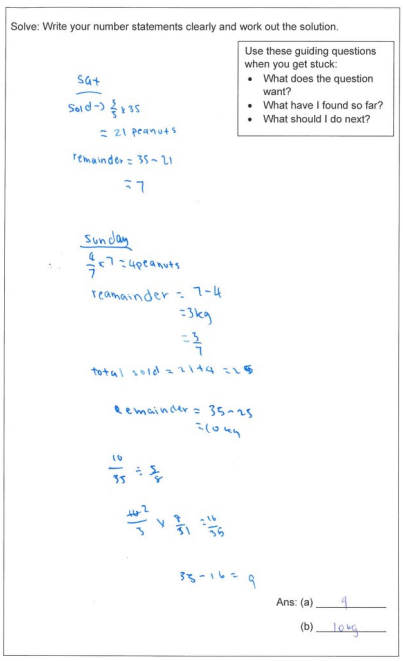


Figure 8. Sample of student workings

Discussion on students' feedback in the interview questions

At the Post test which was conducted in Week 10, students found it easier to answer questions on the algebra concept as compared to questions on the Simultaneous concept. The following methods were used by the students to understand the problem situations in the given problems:

- Apply Polya processes
- Re-read the word problem a number of times to fully understand the situations occurring in the word problem;
- underline keywords
- follow the sequence of events stated in the word problem scenario to have a clear picture about what is happening in the problem

The strategies used in solving the problems were:

- Work backwards from the last event to the first event; Draw a model; List and Act out the steps in sequence; Write mathematics statements - unitary method.

- When stuck in a challenging word problem, the students would read and reread the problem a few times to mentally visualise the scenarios in the question;

- draw pictures; use a strategy the child is comfortable in using and follow the sequence of events presented in the word problem

- For checking, some students put the answer into the question and worked out the solution. Others preferred to work backwards to see if they could arrive at the numbers given in the word problem.

Discussion on Student's Confidence at Pre and Post Intervention

As per the findings, at post intervention students are better able to apply Polya processes to understand questions, plan a solution strategy, solve and self correct. A repeated review of learned concepts has further improved students' ability to understand, plan and solve related word problems.

Conclusion—has the intervention benefited the students, how can the programme be improved / adjusted to better fulfil the needs of the students (teaching methods, resources)

In conclusion, the intervention has definitely benefited the students in the following ways - Firstly, they were able to complete the post test questions in a shorter time. b Secondly. they were more willing to approach and solve the questions with less apprehension as observed from their manner. Thirdly, they were able to solve the questions more accurately.

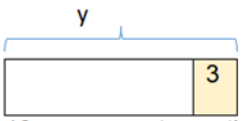
DIRECTIONS FOR FURTHER RESEARCH.

A. Improvements that could be put into place (instructional materials)

- More effort needs to be put in to create introductory activities (CRA in nature) and worksheets to tune in students to the algebra and simultaneous concepts. E.g. To better enable students to visualise situations for the Algebra concept, students could use omnifix cubes in DAS Maths resource / paper folding activity to act out the situations-

- In the question (Algebra concept)

There are y sweets in a packet. 3 sweets are taken out. How many sweets are left in the packet in terms of y?



Students could do a simple paper folding activity - a strip of paper to represent **y** could be folded at one end. The folded part represents the 3 sweets taken out. The number of sweets left in the packet is (**y - 3**) sweets.

For the second part of the question, unfold the 3 sweets part and add on another strip of paper perhaps of a different colour to visualise the situation.

There are (y - 3) + 10 sweets in the packet now.
Let y = 12. How many sweets are left in the packet now?
12 - 3 + 10 = 19. 10 sweets are left in the packet.

With more examples, students can visualise the situations in their mind and just write down the Maths equations and solve the sum.

- In the question (Simultaneous concept):

A pen and 2 pencil erasers cost $9.50. A pen and 4 pencil erasers cost $15.50. What is the cost of a pen?

pen	pencil erasers	amount
1	2	$9.50
1	4	$15.50

pen	eraser	amount
1	2	$9.50
1	4	$15.50

4 - 2 = 2
$15.50 - $9.50 = $6
2 pencil erasers cost $6

$9.50 - $6 = $3.50

A pen costs **$3.50**

- Students can use omnifix cubes - different colours to represent pen and pencil eraser to act out the situation presented in the word problem.

  For the representational stage, instead of writing mathematics equations and then eliminating the common multiple, students can insert the data into a table and solve the sum.

B. Improvements to Research Design

Improvements can be made to the research design of the case study as well. 8 students participated in the current study. Future studies could use a bigger sample size. Questionnaires could also be developed to ensure that students are able to easily understand and answer the questions. Questionnaires could also use options such as ticks or multiple choice instead of open ended questions so as to make it easier for students to answer the questions!

CONCLUSIONS

A case study approach to evaluating the PSUP approach to problem solving at DAS in Singapore has revealed the full potential of this system in addressing the known issues for dyslexic students in processing word problems. Further refinements to the system have been suggested to improve the impact in ongoing research.

REFERENCES

Badian, N. A. (1999). Persistent arithmetic, reading or arithmetic and reading disability. *Annals of Dyslexia, 49*, 45– 70.

Chinn, S. J. (ed.) (2015). *The Routledge International Handbook of Dyscalculia and Mathematical Learning Difficulties*. London. Routledge.

Dyslexia Association of Singapore. (2022), *SES MATHS PROGRAMME* [Online]. Available at: https://www.das.org.sg/services/programmes/maths.html#teaching-approach (Accessed: 19 May 2022).

Dyslexia Association of Singapore. (2022a), *SES MATHS PROGRAMME–teaching approach* [Online]. Available at: https://www.das.org.sg/services/programmes/maths.html#overview (Accessed: 19 May 2022).

Dyslexia Association of Singapore. (2022b). *What is Dyslexia?* [Online]. Available at: https://www.das.org.sg/ (Accessed: 19 May 2022).

Dyslexia Association of Singapore. (2022). *Problem Sums for Upper Primary* [Online]. Available at: https://dyslexia.org.sg/news-events/blogs/182-maths-teaching-and-learning/491-problem-sums-for-upper-primary.html (Accessed: 19 May 2022).

Hipwell, E. N. D., (2022). *How Dyslexia affects Math* [Online]. Available at: https://thinkaplus.com/how-dyslexia-affects-math/ (Accessed: 19 May 2022)

Joyner, R., & Wagner, R. (2019). Co-occurrence of reading disabilities and math disabilities: A

meta-analysis. *Scientific Studies of Reading, 24,* 14–22.
Landerl, K., & Moll, K. (2010). Comorbidity of learning disorders: Prevalence and familial transmission. *Journal of Child Psychology and Psychiatry, 51*(3), 287–294. https://doi.org/10.1111/j.1469-7610.2009.02164.x
Lee, N. H. (2008). Nation building initiative: impact on Singapore Mathematics curriculum. In M. Niss (Ed.), *10th international congress on mathematical education proceedings* (CD). Copenhagen: Roskilde University.
Maloney, E. A. (2012). Math anxiety: who has it, why it develops, and how to guard against it. *Trends Cogn. Sci. 16*:526. doi: 10.1016/j.tics.2012.06.008
Ministry of Education. (2006). *A guide to teaching and learning of primary mathematics 2007*. Singapore: Ministry of Education Curriculum and Planning Division
Moser, J. M. (1992). Arithmetic operations on Whole numbers: Addition and Subtraction.
Mugnaini D., Lassi S., La Malfa G., & Albertini, G. (2009). Internalizing correlates of dyslexia. *World J. Pediatr. 5*,255–264. 10.1007/s12519-009-0049-7
Ng, W. L. (2008). *Problem solving heuristics for primary school mathematics: A comprehensive guide.* Singapore: Pearson.
Nicolson, R.I., & Fawcett, A. J. (2007). Procedural Learning Difficulties: Re-uniting the Developmental Disorders!? *Trends in Neurosciences, 30*(4), 135-141.
Po'lya, G. (1962). *Mathematical discovery*. New York: Wiley.
Po'lya, G. (1971). *How to solve it* (2nd ed.). Princeton, NJ: Princeton, University Press.
Reynolds, A. E., & Caravolas, M. (2016) Evaluation of the Bangor dyslexia test (BDT) for use with adults. *Dyslexia, 22* (1), pp. 27-46, 10.1002/dys.1520
Rhodes, S. (2019). *How Did You Solve It? Metacognition in Mathematics* [Online]. Available at: https://www.ascd.org/el/articles/how-did-you-solve-it-metacognition-in-mathematics (Accessed: 19 May 2022).
Snowling, M. J., Moll, K., & Hulme, C. (2021). Language difficulties are a shared risk factor for both reading disorder and mathematics disorder. *Journal of Experimental Child Psychology, 202*, Article 105009. https://doi.org/10.1016/j.jecp.2020.105009
Van de Walle, J. A. (2004). *Elementary and middle school mathematics: Teaching developmentally.* New York: Pearson Education Inc

APPENDIX 1: Student questionnaire on their confidence level (Questions 1 to 3).

Problem Sums for Upper Primary PSUP

Student questionnaire

Name _____ Date_____

Answer the following questions as best as you can

1. On a scale of 1-5, How confident are you in solving Mathematics problem sums?
   Circle the number on the scale:

	|_____|_____|_____|_____|_____|					
Not confident	0	1	2	3	4	5	*Very confident*

2. Which of these strategies do you use when solving Mathematics problem sums?
   Tick the strategy

Working backwards		Assumption method	
Listing		Before/ After	
Draw a diagram		Unitary	
Act it out		Simplify the problem	
Guess and Check		Solve part of the problem	
Look for a pattern			

3. How often do you apply these POLYA processes for solving problems?
   Circle one of the following on the scale:

UNDERSTAND THE PROBLEM

\|_____\|_____\|

I don't need to *Sometimes* *Always*

PLAN A SOLUTION STRATEGY

\|_____\|_____\|

I don't need to *Sometimes* *Always*

SOLVE THE PROBLEM

\|_____\|_____\|

I don't need to *Sometimes* *Always*

CHECK THE SOLUTION

\|_____\|_____\|

I don't need to *Sometimes* *Always*

APPENDIX 2: Interview questionnaire on student thought processes in learning the algebra and simultaneous concepts.

INTERVIEW QUESTIONS

SCRIPT PRIOR TO INTERVIEW:

Dear student, thank you for being willing to take part in this interview aspect of this research project at the DAS. This study seeks to find out about the experiences of our students on the Problem Sums for Upper Primary programme and to measure the effectiveness of the programme.
Our interview today will last about 10-15 mins and I will ask you questions about the programme as well as about the test you have just completed. In class, you completed a consent form indicating that I have your permission (or not) to audio record our conversation.

Are you still ok with me recording (or not) our conversation today?

_____ YES _____ NO

IF YES: Thank you! Please let me know if at any point you want me to turn off the recorder or keep something you said off the record.

IF NO: Thank you for letting me know. I will only take notes of our conversation.

Let's begin.

PART 1

1. On a scale of 1 to 5, how easy was this test for you?
   1 being very easy, 5 being very difficult.
2. Which question did you find the easiest?
3. Which question (s) did you find challenging?

PART 2

4. Let's walk through some of the questions. I would like you to describe to me in detail what went through your mind when you saw Question 1 (*Algebra question).*
5. What strategies did you use to help you understand this problem?
6. Was the strategy you used helpful? If not, what did you do?
7. Can you tell me more about the sequence of steps you took to solve this problem?
8. What happens after you had carried out your steps? What did you do to check your work?
9. How easy or difficult did you find this question?
   1 being very easy, 5 being very difficult
10. Let's move on to Question 2 *(Simultaneous Question).*
    Can you describe to me in detail how you approach this question?
11. What strategies did you use to help you understand this problem?
12. Was the strategy you used helpful? If not, what did you do?
13. Can you tell me more about the sequence of steps you took to solve this problem?
14. What happens after you have carried out your steps? What did you do to check your work?
15. How easy or difficult did you find this question?
    1 being very easy, 5 being very difficult.

PART 3

16. Let's look at one of the questions you found challenging. Could you tell me why this question was challenging for you?
17. Could you describe how you approached this question?
18. At which point did you get stuck? What did you do then?

PART 4

19. You have attended our Problem Sums class for 1 term. How do you find the lessons?
20. What are some strategies you have picked up from our lessons?
    (a) How likely will you use these strategies in your schoolwork?
        1 not at all, 5 I will definitely use them.
    (b) Tell me why you chose this score.
21. What do you like about the Problem Sums for Upper Primary (PSUP) lessons?
22. How can we improve our lessons for future batches of students?
23. Thank you for your participation. We have come to the end of the interview.
24. Do you have any questions to ask?

If not, thank you and you may take your leave.

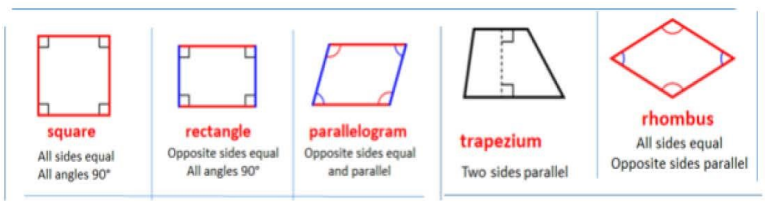
APPENDIX 3: Student Worksheet structure

PROBLEM SUMS FOR UPPER PRIMARY (P5)

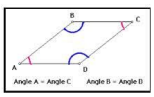
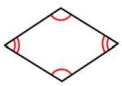
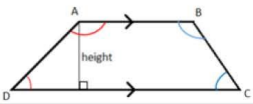
TOPIC/CONCEPT: QUADRILATERALS

Learning Outcomes

Students to be able to find the unknown angles in the Geometric figures using the properties of 4- sided **quadrilateral** figures:



* each angle of the square/rectangle is a right angle - 90°

Parallelogram	Rhombus	Trapezium
		
• Opposite sides are parallel. • Two pairs of parallel sides. • Opposite angles are equal. • Each pair of angles between the two parallel sides add up to 180 °	• All the sides are the same length. • Opposite sides are parallel. • Two pairs of parallel sides. • Opposite angles are equal. • Each pair of angles between the two parallel sides add up to 180 °.	• Opposite sides are parallel. • The pair of angles between the two parallel sides add up to 180 ° Angle A + Angle D = 180 ° Angle B + Angle C = 180 °

Instructions to students:

- ❖ Read the story in the sums meaningfully.
- ❖ Work through each sum systematically using the following approach:
  - Understand the problem
  - Devise a plan
  - Carry out the plan
- ❖ Check the solution
- ❖ Enjoy the sums!

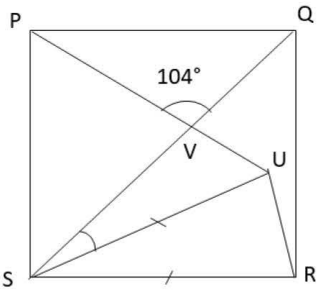
Name: _____ Date : _____

QUADRILATERALS

Name: _____(P5) Date: _____

Word Problem ①

In the figure, PQRS is a square.SR = SU, PVU and QVS are straight lines.
If ∠PVQ = 104°, find ∠VSU.



Understand the problem (*write the given essential information*)

1. _____

2. _____

3. _____

4. _____

What the question wants me to find:

1. _____

2. _____

When you have finished your work, check your solution using these questions:

Please tick (√)	
	Have I answered the question?
	Do my working steps and answer(s) make sense?
	Did I copy the numbers correctly from the question to my workings?
	Are my calculations accurate?
	Did I write the correct units in my answer?

Solve: Write your number statements clearly and work out the solution.

Use these guiding questions when you get stuck:

- What does the question want?
- What have I found so far?
- What should I do next?

Ans: _____

3

Asia Pacific Journal of Developmental Differences
Vol. 10, No. 1, January 2023, pp. 65—97
DOI: 10.3850/S2345734123000336

Executive functioning, study skills, and dyslexia - Examining the effectiveness of an online programme for upper secondary and post-secondary students

Rosalyn Wee[1] and Serena Abdullah[1*]

1. *Dyslexia Association of Singapore*

Abstract

As students transition to higher education, study skills, executive functioning skills, and life skills, are an important set of transferable skills in enabling them to learn and work more efficiently under more demanding conditions, thereby maximising their potential as well as the full benefit of their time and effort. Therefore, as dyslexia is a life-long learning difference, there is a need for specialist support even as individuals at risk or diagnosed with dyslexia transits into post-secondary education or tertiary education. Certainly, with the acquisition and competence in essential study skills and techniques, these students may become self-directed, independent and responsible learners, which are invaluable traits and characteristics for any tertiary learner. More importantly, these skills provide a strong foundation for them to be able to reach their goals and aspirations not only in school but also in their future workplace. The English Language and Literacy Division (ELL) at the Dyslexia Association of Singapore (DAS) developed the iStudySmart™ programme, which adopts an online learning approach that aims to empower students with learning differences in the areas of time management and prioritisation, planning and organisation, tertiary writing and presentation skills. The aims of iStudySmart™ were not only to bridge the gap in intervention and resources catered for students with learning challenges at the tertiary level but also to keep abreast with changing times, demands and expectations observed in the education sector. This paper evaluates the relevance and effectiveness of iStudySmart™ and also measures student self-confidence, motivation, and independence through the administration of pre- and post-questionnaires and a post-questionnaire or interview six months after. Further, qualitative data comprising testimonials from parents revealed high levels of satisfaction and recognition of the value of the online approach. Results from post-questionnaire and interview six months after indicate that all aspects of the iStudySmart™ intervention were effective, with moderate and large effect sizes for planning and organisation, tertiary writing and presentation. On the other hand, time management and prioritisation strategies learnt through the programme would need more time and practice before students can apply these in their daily lives.

Keywords: higher education, dyslexia, specific learning difficulty, study skills, motivation, executing functioning skills, independence, self-confidence, e-learning, online learning, flipped classroom, asynchronous learning, synchronous learning

***** *Correspondence to:*
Serena Abdullah, Assistant Director (Curriculum/Resource), English Language and Literacy Division & Lead Educational Therapist, Dyslexia Association of Singapore Email: serena@das.org.sg

INTRODUCTION

Dyslexia is a life-long learning difference (Ramus et al., 2003). According to international prevalence rates, 10 percent of a population have dyslexia, of which four percent have dyslexia severe enough to warrant immediate intervention. Based on the European Dyslexia Association (n.d.), dyslexia occurs worldwide regardless of culture or language and it affects nine to 12 percent of the population whereby two to four percent of the population can be seriously affected by it. Further, as cognitive challenges associated with dyslexia persist into higher education and adulthood (Hatcher et al., 2002), awareness, specialist support and resources should ideally continue to be made available and accessible for students with dyslexia and other specific learning differences in the higher education environment.

In recent years, there has been a greater emphasis placed on awareness raising campaigns on dyslexia and other specific learning differences in Singapore. Hence, there are now more students with learning challenges being identified in pre-school, primary school or even secondary school. This enables them to access specialist programmes and services such as the school-based dyslexia remediation programme offered in Singapore government schools, or educational therapy at the Dyslexia Association of Singapore (DAS) to help them cope with their literacy challenges.

The Current Gaps in Higher Education

For students with learning differences, their literacy challenges that include reading, comprehension, spelling and writing may persist throughout their lifetime. For some students, they may be able to overcome their difficulties with compensatory strategies, but for others, the compensatory strategies may not be sufficient to help them cope with the more demanding and rigorous academic experience and expectations in higher education.

Unfortunately, as students transition to Institutes of Higher Learning (IHLs), academic demands do not only increase but specialist support, resources and awareness may not be as prevalent and accessible especially in supporting tertiary students with dyslexia and other specific learning differences (Dobson Waters & Torgerson, 2021; MacCullagh et al., 2017; Mortimore & Crozier, 2006; Olofsson et al., 2015; Pino & Mortari, 2014).

Singapore has continued to advocate and show its commitment in building a more inclusive society and education system, which includes supporting tertiary students with special educational needs (SEN) in IHLs. IHLs have SEN offices that coordinate support and provide guidance to students from pre-enrolment to graduation (Ministry of Education, Singapore, 2021).

A study conducted by Hewes (2020) revealed that participants who achieved a university education reported their tertiary learning experience to be a positive one as they have become matured. Hence, learning seems much easier and manageable. They also pursued subjects and specialisations of their interest and passion (West, 2014).

While Singapore is certainly on a path towards embracing diversity and inclusion in higher education settings, there are still gaps that need to be addressed and bridged in order to better support students with learning challenges and see them through their journey in completing their tertiary education. Therefore, it is vital for educational policies to be reviewed and implemented in ensuring that individuals with specific learning differences receive the necessary support and resources at all educational levels including higher education, to experience a more positive and fulfilling learning experience.

Taking into consideration the prevalence rate and that tertiary students with dyslexia are likely to continue to struggle with keeping up with the learning pace and academic rigour in IHLs, the iStudySmart™ programme was developed by the DAS primarily to support this population of students.

The iStudySmart™ Programme

The iStudySmart™, a two-term six months online learning programme, was developed at DAS to support tertiary students with learning differences, and upper secondary students transitioning to tertiary education to gain skills that extend beyond literacy intervention. The programme combines e-learning to allow students to access the content material at their own learning pace as well as online consultation sessions for more personalised support and guidance. As the e-learning and online consultation sessions are all online, the paper will use the term '**online learning'** throughout the paper.

The online learning pedagogy comprises different approaches such as multi-modalities and Orton-Gillingham teaching principles. These include being direct and explicit, diagnostic and prescriptive, structured, sequential and cumulative (Gillingham & Stillman, 1997). The pedagogical principles have been built into the design of the online content and execution to ensure that the students accessing the course materials are able to do so with greater independence and ease. iStudySmart™ also covers study skills, executive functioning skills and life skills that include time management and prioritisation, planning and organisation, tertiary writing and presentation skills.

The tertiary writing module, for instance, guides and teaches students how to effectively research for information (based on a research topic), evaluate the validity and reliability of sources as well as cite and reference the sources used in their research, which can be applied to their own assignments and research projects. Additionally, developing good public speaking/presentation skills i.e. being able to present confidently and coherently

has become an expectation at the tertiary level (Nash, Crimmins, and Oprescu 2016), as well as workplaces where making presentations is a commonplace. Good public speaking or presentation skills are critical communication skills which are part of the 21st century skill frameworks which will not only help students including those studying in IHLs cope better with the academic rigour but also stand them in good stead when they enter the workforce in the future (Hunt et al., 2019). The programme culminates in a final project presentation where students will present their research topic to an audience that includes fellow peers, teachers, and parents.

Since the inception of the programme in 2019 till the end of 2020, 41 students who have varied learning profiles and learning needs have received specialist intervention on iStudySmart™. The majority of the students were from Institutes of Technical Education (ITEs) and Polytechnics and all of them have a dyslexia diagnosis. For some of them, some of them also have other co-occurring challenges which include speech and language impairment (SLI), Autism Spectrum Disorder (ASD) and Attention Deficit Hyperactivity Disorder (ADHD) in addition to their dyslexia diagnosis. Further, the common learning challenges observed in most students include:

- gaps in executive functioning skills i.e. poor time management, prioritisation and organisation skills
- difficulties in communication, tertiary writing and presentation skills

REVIEW OF LITERATURE

Dyslexia

DAS is guided in its definition of dyslexia by two important sources which includes the Rose Report from the United Kingdom - Rose (2009), the United State's Department of Education Report on the Individuals with disabilities education act (2011). The definition is as follows:

> "Dyslexia is a type of specific learning difficulty identifiable as a developmental difficulty of language learning and cognition. It is a learning difficulty that primarily affects the skills involved in accurate and fluent word reading and spelling. Characteristic features of dyslexia are difficulties in phonological awareness, verbal memory and processing speed. Co-occurring difficulties may be seen in aspects of language, motor co-ordination, mental calculation, concentration and personal organisation, but these are not, by themselves, markers of dyslexia."

Dyslexia in Higher Education

While a general understanding about dyslexia in higher education has increased, students with learning challenges appear to feel that they do not receive enough support (Dobson Waters & Torgerson, 2021; Griffin & Pollak, 2009). According to the Office for Students (2017), students would have to make the request for inclusive learning to help them in their academic studies rather than the inclusive practices being already in place and implemented. Students also reported inconsistency in support between the support staff and faculty staff (Higher Education Funding Council for England Report, 2015). The existing gaps prompted the need for specialist intervention programmes like iStudySmart™ to be developed and implemented to support students with dyslexia in higher education including Upper Secondary students to prepare and support them through their transition to tertiary education.

There is also little literature and research on students with learning disabilities (LD) despite their increasing number in higher education settings (Carlisle, 2022; Heiman & Precel, 2003; Sparks & Lovett, 2009). There is also little research to evaluate the effectiveness of the support and intervention rendered to the students at IHLs (Dobson Waters & Torgerson, 2021). The limited research and evidence-based practices for learners with dyslexia at IHLs conceivably disadvantages faculty staff who need more information to support students experiencing academic difficulties such as those with reading and writing gaps (Quick, 2013).

However, reading and writing skills continue to play an essential role in higher education studies (Quick, 2013). Although limited, some researchers have studied how learners with dyslexia cope in tertiary institutions (e.g. Carter & Sellman, 2013; Olofsson et al., 2015) and these studies have demonstrated a correlation between having dyslexia and academic difficulties. Consequently, due to the challenges experienced in reading, spelling and writing, students with dyslexia have reported to have lower self-confidence in their ability to learn (Olofsson et al., 2015).

Additionally, some students struggle with understanding course materials, journal articles, taking notes during lectures (Olofsson et al., 2012) as well as preparing for tests (Kirby et al., 2008). Therefore, being able to develop and possess essential compensatory strategies that includes study skills, time management skills and deep learning approaches (Kirby et al., 2008) may help them better manage their difficulties.

Moreover, the lack of appropriate support from the disability office as well as limited awareness of dyslexia among academic staff (MacCullagh et al., 2017; Mortimore & Crozier, 2006; Olofsson et al., 2015; Pino & Mortari, 2014) have also been identified as barriers by students.

Rowan (2014) also found that students with dyslexia may lack the knowledge and skills to

self-advocate. As a result, they may not adequately express their needs to request guidance and appropriate accommodations to support their university studies.

As students with dyslexia and other specific learning differences may continue to struggle and face academic difficulties in IHLs, having access to support, specialist services and resources as well as developing stronger advocacy skills are therefore critical in helping them navigate their challenges and overcome obstacles to experience success in their academic pursuit.

Dyslexia and Executive Functioning

The ability to perceive and estimate the duration of an interval, either retrospectively or prospectively, is vital in helping individuals organise their time more efficiently. In other words, having good time management optimises one's daily performance and productivity. It not only helps with meeting deadlines and schedules but also aids with organising tasks and assignments based on their level of importance and urgency.

According to Barkley (1997), time estimation is an executive ability that enables an individual to perform and deliver tasks optimally within a given time frame. It, therefore, has a bearing on how efficient and productive an individual is especially with higher expectations, limited amount of time and considerable assignments and projects (Rosenblum, 2012) that typically come with being in higher education institutions. Furthermore, there are deficits in explicit and implicit time estimation among the dyslexia population which might be due to specific impairments in their 'internal clock' (Casini et al., 2018; Nicolson et al., 1995). This means that students with dyslexia might overestimate the time they have to complete a complex task. In addition to difficulties with time estimation, language processing and short-term memory deficits associated with dyslexia further compound the difficulties learners with LD face when it comes to processing information the first time round, especially if the information comes at a high speed or if the task is complicated in nature.

Executive functions (EF) are higher-level cognitive functions which comprise two close but separate executive abilities: meta-cognitive ability and motivational-emotional ability (Ardila, 2008; Dawson & Guare, 2004). According to the literature, individuals with LD show gaps in EF (Compton et al., 2012; Horowitz-Kraus, 2014; Varvara et al., 2014) especially in areas related to time management, working memory, planning and organisation (Brosnan et al., 2002; Dahan et al., 2008; Fleming & McMahon, 2012; Trainin & Swanson, 2005).

In addition, activities and tasks that require more executive processes resulting in the need to allocate more attentional resources may also impact the efficacy of event-based prospective memory (Marsh & Hicks, 1998). Given reports that show how learners with dyslexia struggle with automatisation and attention (Nicolson & Fawcett, 1990), such

impairments are likely to affect naturalistic prospective memory settings (Smith-Spark et al., 2004).

Furthermore, deficits in EF may also affect educational success as EF has been linked to academic performance in learners of different age groups with and without specific learning differences (SpLD) (see Best et al., 2009, and Müller et al., 2008, for reviews).

Dyslexia and Study Skills

Study skills are essential for learning independently and effectively, including acquiring purposeful skills and knowledge at various levels of education (Jones et al., 1992). Study skills, a form of metacognitive processing, help students process and internalise information, retain and apply the acquired knowledge as well as produce new information in a meaningful way (Al-Hilawani, 2016).

The acquisition and application of study skills have therefore been positively associated with academic achievements (Hoover, 1989, Miranda et al., 2022). Some research also suggests that students who have inadequate study skill techniques with or without learning differences are likely to be at risk of underperforming (Proctor et al., 2006; Reaser et al., 2007) as they may be unprepared for a successful college education.

Dyslexia and Online Learning

Traditionally, before COVID-19, most learners and educators have a certain time to meet which means that synchronous learning takes place. However, with technology-enhanced learning techniques after the 1980s, there was an academic shift towards constructivist learning together with technology-enhanced learning techniques (Alpat, 2019). This was especially so after COVID-19. Such techniques that incorporate constructivist learning may include online learning which includes e-learning, or blended learning which is a combination of online learning and face-to-face learning.

E-learning, a subset of online learning, is a structured course of learning content delivered electronically and is usually managed and administered using a learning management system (LMS) usually accessed using a web browser (Foreman, 2017). Some common LMS might include Blackboard or Moodle. Learning on an LMS is asynchronous which means it is self-paced and the learners take the course on their own. On the other hand, synchronous online learning is educator-led and takes place at the same time across geographically dispersed areas. It might use web-conferencing or virtual classroom platforms such as Google Hangouts Meet or Zoom which uses the app features such as screenshare, chat, and annotation tools.

It is of utmost importance that the pedagogical approach adopted adheres to the learning styles of learners with dyslexia to better facilitate their learning. Here are some

pedagogical implications derived from studies investigating older learners with dyslexia and how they fared with an online learning approach.

- Learning modes or teaching approach should adapt to older students with SpLDs

Learning styles are commonly defined as "...characteristic cognitive, affective, and physiological behaviours that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment" (Ladd & Ruby, 1999, p. 363). They might also be defined as 'personal qualities that influence a student's ability to acquire information, to interact with peers and the teacher, and otherwise to participate in learning experiences' (Grasha, 1996, p. 41). There have been many studies which challenge the idea of learning styles, but most studies agree that learners have different learning preferences (e.g. Coffield et al., 2004; Mortimore, 2005). It was found that for students with dyslexia, they might benefit from instruction using multimodal learning (Andreou and Vlachos, 2013). Therefore, to accommodate all the different learning styles, it was important for delivery to be multimodal or multi-sensory. This would also mean using appropriate fonts and colours, organising text in slides and handouts, giving instructions, and the staging and scaffolding of videos, such as animations of tutorials and assignments, to be delivered in a multisensorial way.

Other than catering to the students' learning style, it was also important to focus on their profiles. These include focusing on strengths rather than weaknesses when giving feedback in order to build up self-confidence and reduce anxiety (Gallardo et al., 2015). As students with dyslexia also fall on a spectrum, it should not be assumed that students who are older will be able to do well on their own, and help should always be offered.

Learning for students with SpLD should be as authentic as possible to allow students to make sense of their own learning. This is in line with flipped classrooms, based on Piaget and Vygotsky's Cognitive constructivism which states that students should have an active role in the creation of their own reality so that students can make sense of it (Brown, 2001). Students should also be able to learn more effectively, because learning occurs when new experiences are integrated with their existing knowledge or context (Kaufman, 2004). This is especially true when it comes to teaching of life skills or study skills (Alpat, 2019; Durkin & Main, 2002). Therefore, by having flipped classrooms using e-learning as part of the online learning approach, students who are underachieving can help improve their motivation, learning attitude, and engagement which in turn allows them to learn more effectively (Al-Otaibi, 2017; Chou et al., 2021; Nouri, 2016; Cheng et al., 2020).

- The importance of teacher and peer interaction in the learning process

Other than having a good e-learning platform, it was also important that learners be

able to communicate and interact with their teachers online using different electronic devices such as tablets, laptops and smartphones to facilitate communication (Al-Otaibi, 2017; Moore, 2014; Nortvig et al., 2018; Rasskazova et al., 2017; Swan & Shih, 2005). This is so that students can still be motivated and engaged to access the LMS to learn (Rasskazova et al., 2017). This can be achieved through communicating with the students regularly, giving consistent feedback and getting students engaged in critical discussions modelled by the educator (Gray & DiLoreto, 2016).

Other than their teachers, students will need to feel connected not only to the educator but also to other students in the cohort, as well as the course content in order to achieve engagement and learning (Al-Otaibi, 2017; Martín-Rodríguez et al., 2015; Moore, 2014; Nortvig et al., 2018; Rasskazova et al., 2017; Swan & Shih, 2005; Southard et al., 2015). Therefore, in order to build and grow knowledge, teachers can foster feelings of mutual trust through a conscientious effort to build an online community (Cho & Tobias, 2015).

All in all, when interpersonal communication takes place between teachers and students, and their peers, meaning is formed and learning takes place (Tomlinson et al., 2003).

For the purposes of this study, the term **'online learning'** will be used to define the iStudySmart™ programme's mode of learning, which combines elements of e-learning and blended learning entirely through the use of online tools.

METHODOLOGY

Research Questions

What are the effects of an online executive functioning and study skills programme for upper secondary and tertiary-level students with learning differences?:

- **RQ1:** What is the effect of an online executive functioning and study skills programme on executive function, specifically in time management, planning and organisation of students with learning differences?

- **RQ2:** What is the effect of an online executive functioning and study skills programme on tertiary skills (writing and presentation) of students with learning differences?

- **RQ3:** What is the effect of an online executive functioning and study skills programme on the motivation and independence level of students with learning differences?

- **RQ4:** What is the effect of an online executive functioning and study skills programme on perceptions of online learning of students with learning differences?

Participants

Participants included upper secondary and tertiary students (n=28; see Table 1 for breakdown of numbers by school levels) enrolled in the iStudySmart™ programme in 2021. There were a total of 2 intakes and each intake took place for two terms (six months); from January to June and July to December. The students came from mainstream secondary schools, and IHLs which include private universities. 53% of the participants were students from upper secondary where their ages range from 15 years to 17 years old. The remaining 47% were students from higher education institutions with ages ranging from 17 years to 22 years old.

Table 1. Participants from different school levels for Intakes 1 and 2

Intake	School Levels	Number of Students at the beginning of the cycle	Number of Students in total at start of cycle	Number of Students at the end of the cycle	Number of students at the end of cycle
1	Secondary 3	4	15	4	14
	Secondary 4	3		3	
	Upper Secondary	**7**		**7**	
	Institute of Technical Education	5		4	
	Polytechnic	2		2	
	University	1		1	
	Tertiary	**8**		**7**	
2	Secondary 3	4	16	3	14
	Secondary 4	5		5	
	Upper Secondary	**9**		**8**	
	Institute of Technical Education	4		3	
	Polytechnic	2		2	
	University	1		1	
	Tertiary	**7**		**6**	

In Singapore, Students who go to Institute of Technical Education (ITEs) go through technical and vocational training in two or three year courses. Students who do well can apply to attend Polytechnic diploma courses. Students who go to Polytechnics focus more on project-based learning which spans approximately three to four years. They can then apply to attend university degree courses.

Three students exited the programme after one term of intervention. At the end of the programme, one student was not feeling well and did not complete the survey. Therefore, the total number of participants, which included upper secondary and tertiary students, is 27 (n=27).

Instrumentation

Pre- and Post- Intervention Surveys (Quantitative)

The pre and post intervention surveys used in this study was developed following a review of various questionnaires from different studies These include time management (Employability Skills, 2008), presentation skills (Higgins-Opitz & Tufts, 2010), areas of learning difficulties (Learning Disabilities Association of Minnesota., n.d.), and self-efficacy (Research Collaboration, 2015). The post-survey included an additional section to obtain feedback on participant students' overall perception of the programme as well as suggestions on how to further improve the learning experience and outcomes for subsequent intakes of students.

The pre- and post-surveys consisted of 3 main sections:

- Executive functioning skills
- Study skills
- Modes of learning

The pre-survey was administered to the students before the intervention commenced and the post-survey, on the last session. Each survey takes about five to eight minutes to complete.

Interviews- 6 months Post Intervention

As part of ascertaining the level of transference of skills acquired through the programme, a six months post interview was conducted. The interviews took place via Zoom due to the global COVID-19 pandemic. A total of eight students participated, of which two students transitioned to post-secondary right after the completion of the programme. The remaining six students have already embarked on their tertiary education at the point of enrolment. The interview questions provided insight on the

skills and techniques that helped students cope with the increased demands and expectations in their tertiary education.

Table 2. Experimental design

Activity	School Levels	Number of students
6 months Post-interview	Secondary to IHL	2
	IHL to IHL	6
Total number of students		**8**

Testimonials and Feedback (Qualitative)

As most of the participant students may have other co-occurring learning challenges in addition to their dyslexia diagnosis, their progress may be varied and gradual. Therefore, testimonials and feedback provided by parents and Educational Therapists also form an important qualitative aspect in the evaluation of the students' overall progress as well as to triangulate the data.

Intervention

The students received intervention for approximately 20 weeks, two terms in 2021. The first intake took place from January to June and the second intake was from July to December. The intervention combines both e-learning and online learning approaches. Extending beyond literacy intervention, the programme supports and equips students with critical skills to prepare and support them in higher education and future employment. It also aims to bridge the gaps in currently available resources and expertise in IHLs by providing older students access to a specialist programme that caters not only to their learning needs and challenges, but also enables them to become self-reliant, independent and empowered individuals.

Multi-modalities and key teaching principles have also been built into the design and content of the e-learning course materials to cater to learners with learning differences. Depending on the learners' needs and profiles, the online consultation session is another platform where the facilitators would provide differentiated instructions, scaffolding and guidance.

The e-learning elements were designed and developed with careful consideration for secondary school students with dyslexia in anticipation of them needing to adapt to tertiary education and for tertiary students to better cope and thrive in the higher education environment. The content was delivered online on any compatible devices

such as a desktop, laptop, tablet or phone. New content and assignments were uploaded on a weekly basis during the scheduled e-learning weeks. The students would then need to access the course materials at their convenience and pace within the week, spending about 1.5 hours to 2 hours weekly. Additionally, the students do not need to complete the week's course materials and assignments in one sitting. They can continue from where they left off on another day if they need to. Furthermore, they can also review the materials multiple times if they require over-learning and reinforcement in order to gain mastery in any of the skills and techniques taught.

The core modules covered include skills in the following areas:

Time Management and Prioritisation	Students will be taught how to manage their schedule and tasks based on the level of importance and urgency.
Planning and Organisation	Students will be guided on how to plan and organise ideas based on a chosen research topic.
Tertiary Writing	Students will learn how to gather, synthesise and organise relevant information.
Presentation	Students will grow and become a better and more confident speaker.

13 e-learning sets of materials were storyboarded by the two researcher-facilitators. Using Articulate 360, these learning materials were developed into Shareable Content Object Reference Model (SCORM) packages by an instructional designer who is also an Educational Therapist (EdT). All of the SCORM packages were uploaded on the e-learning platform for the students to access.

The SCORM packages consist of various multi-modal strategies including videos, interactive elements, closed captions, where possible, to increase engagement and sustained concentration among the students. Concept checking elements such as quizzes were also incorporated to further heighten students' understanding and hopefully, enable greater transference of skills across relevant domains. This is in line with Piaget's and Vygotsty's concept of cognitive constructivism which was discussed in the literature review earlier.

In addition to the e-learning content, there were a total of six stipulated face-to-face online consultation sessions scheduled over the course of twenty weeks. During these sessions, the facilitators would meet with their assigned students virtually to provide the necessary support and guidance. The students would also be able to clarify any questions they have regarding the course materials or assignments.

Should any of the students require extra help based on their varied learning profiles, the facilitators may arrange for additional sessions to support the student in order to help them to understand the e-learning content or assignment instructions. The facilitators also conduct weekly check-ins with the students and work closely with their parents via various communication channels such as emails and text messages.

Further, the intervention culminated in a live final presentation where the students not only presented the content of their research. but were also exposed to questions posed by the judges during the Question and Answer segment.

FINDINGS AND ANALYSIS

Students were asked to rate their responses across a Likert scale of 1 representing "never" and 5 which is "all the time". These are the findings from the pre- and post-questionnaires.

Overall Findings - Pre- and Post-Surveys: Tertiary and Upper Secondary School Students

Comparison between the students' pre-intervention and post-intervention scores were established in order to evaluate whether there have been any gains. T-scores and effect sizes were also calculated on selected questions from each module to have a better understanding of the level of progress i.e. significant, minimal or no improvement demonstrated by the students. Effect sizes are used where sample sizes are moderate, in order to compare between different questions, with an effect size of 0.2 representing a small effect size, 0.5 a moderate effect size, and 0.8 a large effect size (Cohen, 1988)

T-scores were calculated to show the difference between the student population before and after the intervention. Based on the t-scores calculated, the calculated t-score for the question, "I prioritise my tasks so that I do the most important and urgent ones first" was greater than the table value at an alpha significance level of .05 (which means it was non-significant. For the rest of the questions above, the t-scores generated were smaller than the alpha significance level of .05 (which means that answers before and after the intervention were significant and the null hypothesis (H0) is rejected.

After two terms of intervention, it was found that the effect sizes for the following modules, Planning and Organisation Skills, Tertiary Writing Skills and Presentation Skills were 'moderate' to 'large'. The effect size was small for Time Management and Prioritisation Skills.

Table 3. T-scores, P-value and Effect Sizes for various study skills

Study Skills	**Time Management and Prioritisation Skills**		**Planning and Organisation Skills**		**Tertiary Writing Skills**		**Presentation Skills**	
Question	I review my progress towards my goals every now and then and revise my plans accordingly.	I prioritise my tasks so that I do the most important and urgent ones first.	I break difficult tasks down into smaller components so that I can accomplish them one step at a time.	I am able to moderate my distractions and not affect the completion of my task.	I know how to find relevant information from various sources (e.g. internet, newspapers & books, etc.).	I know the structure and language features of a speech.	I feel confident presenting after a lot of practice.	I know how to create appealing visual aids (i.e. Google Slides) to help me in my presentation
T-scores	0.04*	0.15	0.01**	0.01**	0.04*	0.00***	0.03*	0.00***
P-value	*	nil	**	***	*	***	*	***
Effect Sizes	0.4 Small	0.3 Small	0.8 Large	0.7 Moderate	0.7 Moderate	0.82 Large	0.5 Moderate	0.9 Large

In table 3 above, * represents that the P-value is significant at <.05, ** significant at <.01 and *** significant at <.001.

RQ1: What is the effect of the iStudySmart™ online programme on executive function, specifically in time management, planning and organisation of students with learning differences?

- Time Management and Prioritisation skills

As the effect size score was low for both questions 'I review my progress towards my goals every now and then and revise my plans accordingly' and 'I prioritise my tasks so that I do the most important and urgent ones first', responses from two other questions in this category were identified to determine if the students had shown any gains and progress in managing their time and prioritising their tasks more efficiently. The two questions were:

- I have a daily to-do list that I update regularly.
- I am able to prioritise important tasks and complete them.

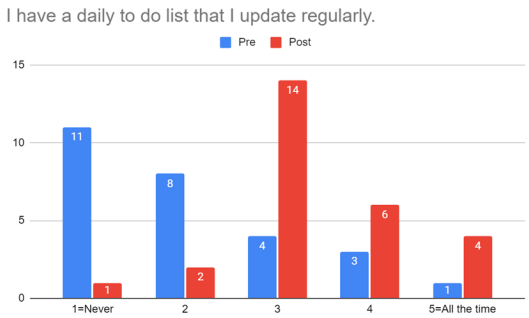


Figure 1. The use of a 'to-do list'

Based on the results obtained as seen in Figure 1 above, most of the students did not update their daily to-do list before the intervention. They were also not aware of how to prepare a to-do list or schedule and update it regularly, to help them better manage their time and prioritise their tasks more productively. However, there have been some gains observed post-intervention with 14 students rating their response as '3' and 10 students rated '4' or '5' for this question. Additionally, it is noteworthy to highlight the marked improvement demonstrated by the students after they have received support as compared to pre-intervention when the majority of the students then rated '1' or '2'.

A further analysis of the results was conducted to see if there were any difference in gains between the upper secondary and tertiary groups students.

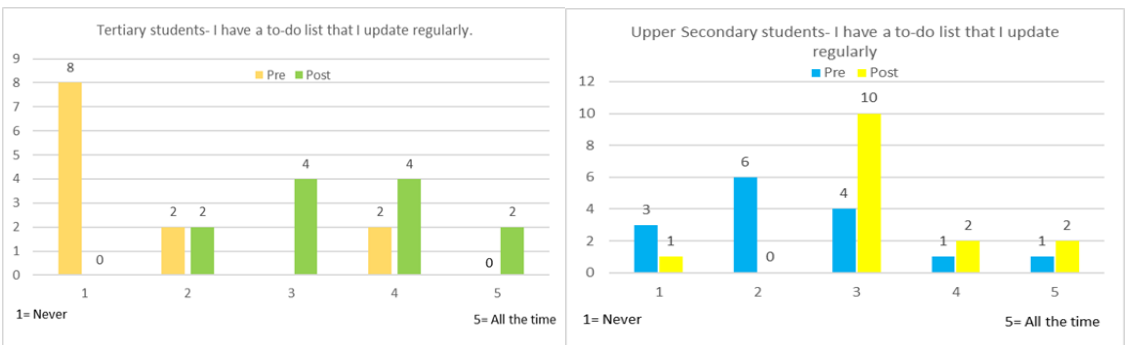


Figure 2. Comparison of Tertiary and Secondary students for the use of 'to-do list'

Based on Figure 2, it can be inferred that most of the IHL students as compared to the Upper Secondary students did not have the habit of preparing a to-do list pre-intervention to help them take note of which tasks to prioritise and complete within a stipulated timeline. This is in spite of them being in higher education where workload tends to be more intense. On the whole, both groups have demonstrated awareness and knowledge post intervention in creating to-do lists to help them better plan and organise their tasks with IHL students making greater gains.

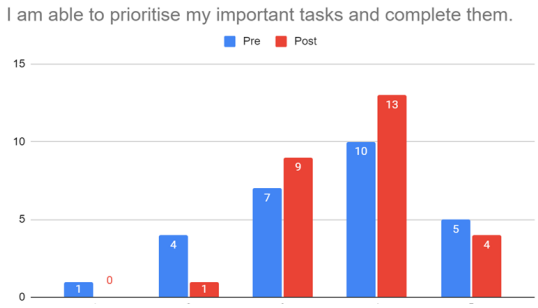


Figure 3. Ability to prioritise tasks

From Figure 3, most of the students have also shown improvement in their ability to prioritise and complete tasks that are more important and urgent in order to meet stipulated deadlines. More than half of the students have rated either 'Most of the time' or 'All the time' post intervention. While the effect size for the 'Time Management and Prioritisation Skills' module is small, there was still some progress and gains demonstrated by the majority of students.

Furthermore, the post 6 months interview responses have also shown that the students benefited from learning how to better prioritise their tasks, which in turn, allows them to manage their time more efficiently given the increased workload and assignments expected of them to undertake in tertiary education.

> *" iSS [iStudySmart™) really helped in time management and prioritising different tasks."*
>
> *"Time management is different [in higher education]... now I set a goal to finish [my work] at least 2 days before [the deadline] to overcome procrastination."*
>
> *"I learnt time management skills which [has] helped me as polytechnic [student] as [learning] is more self-directed."*

Planning and Organisation Skills

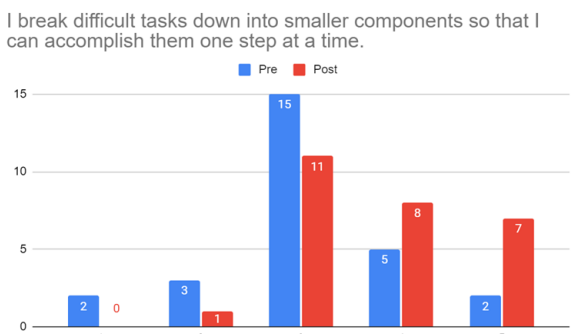


Figure 4. Ability to break tasks down

Referring to Figure 4, we can gather that prior to receiving intervention, most of the students do not know how to effectively manage their tasks, especially if they are challenging or demanding to complete. After the intervention, most of them now possess the awareness and ability to break down tasks into bite-sized ones in order to make the process of completion more manageable and less overwhelming for them.

As shown in Figure 5 above, both groups of students have demonstrated significant gains after receiving intervention and therefore, are more independent and confident in undertaking tasks especially those that are challenging or complex in nature. They also demonstrated similar progression patterns.

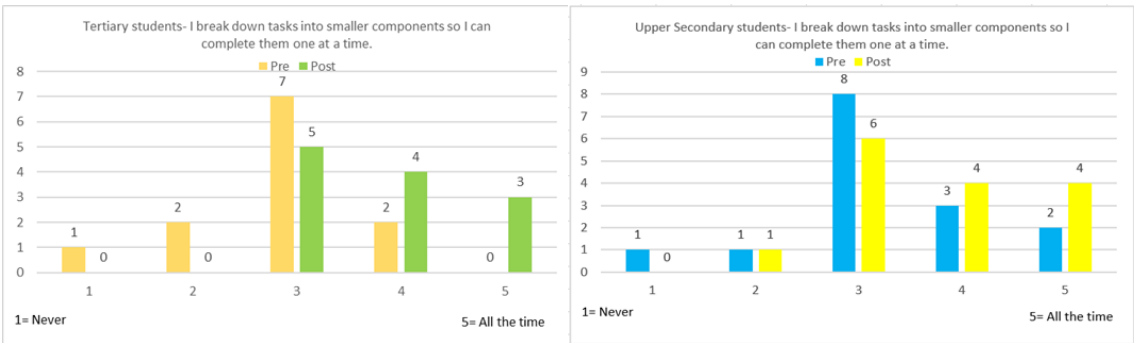


Figure 5. Comparison of Tertiary and Secondary students on their ability to break down tasks

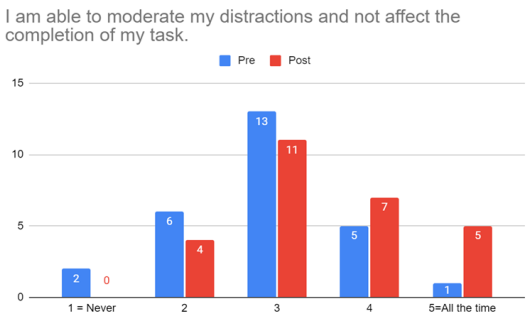


Figure 6. Ability to moderate distractions

While most of the students are still in the process of developing self-discipline and the ability to focus in order to see to the completion of their tasks without being distracted, it is still noteworthy to highlight that close to half of the students have reported improvements in their ability to moderate their distractions post intervention. Seven students chose 'Most of the time' and five students chose 'All the time' for this question.

RQ2: What is the effect of the iStudySmart™ online programme on tertiary skills (writing and presentation) of students with learning differences?

Tertiary Writing Skills

Students with dyslexia would generally experience difficulties when it comes to searching for relevant information to justify their points or arguments for their research. They may not know how to identify keywords that would help narrow the scope of research as well as discern information that is valid and reliable. From the Figure 7, there is certainly a positive increase in the students' confidence and ability to conduct research more effectively and independently.

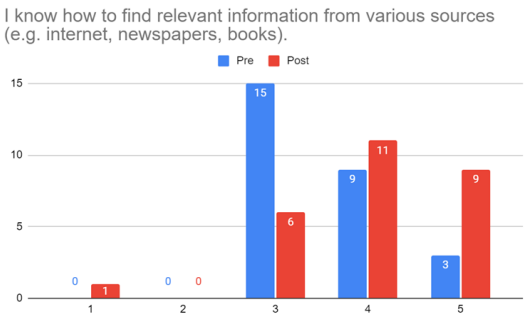


Figure 7. Knowledge of finding relevant information

The post interviews also revealed similar findings.

> *"The iSS [iStudySmart™ programme] taught me how to [cite] using APA [format] which is used by my school."*
>
> *"...how to source good materials online for any presentations."*
>
> *"The iSS [iStudySmart™ programme] [provides] a good foundation for research because when you are in polytechnic, there's a lot of [research assignments] especially for the mandatory modules."*

While the IHL and Upper Secondary groups of students have demonstrated progress in their ability to search for relevant information for research post intervention as shown in Figure 8, the IHL group has shown more gains. This could be due to the fact that IHL students have more opportunities to be involved in research or project work compared to Upper Secondary students. Thus, they are able to have more practice in applying the skills acquired in searching for information relevant to their area of research.

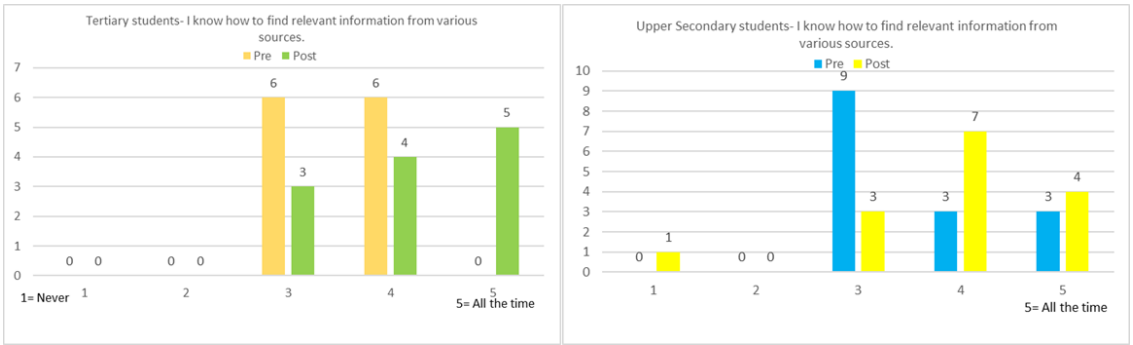


Figure 8. Comparison of Tertiary and Secondary students regarding finding relevant information

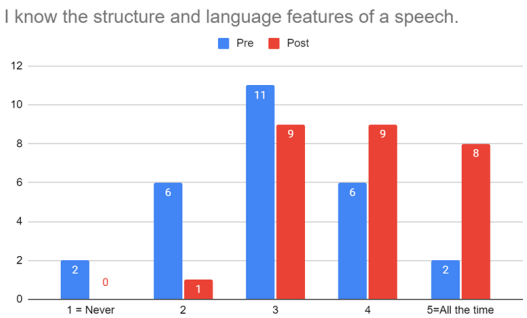


Figure 9. Knowledge of the structure of speech

It can be seen from the students' responses in Figure 9 that after receiving intervention, there was a significant positive increase in the students' perspectives and knowledge about the structure and language features of a speech for oral presentations.

- Presentation Skills

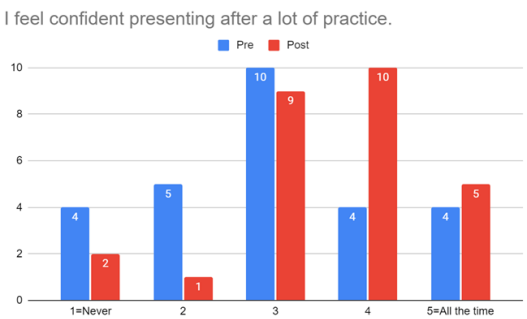


Figure 10. Confidence in giving oral presentations

In terms of the confidence gained with making presentations, more than half of the students have made either large or moderate gains. The results suggest that while making presentations may seem challenging and daunting to students with dyslexia especially if they do not have much exposure in public speaking, they gain more confidence when ample practice and guidance is provided to them.

As seen in Figure 11, prior to intervention, most of the students provided a neutral response '3' when it came to creating slides that are appealing, to support their oral presentation. In other words, they may not know how to incorporate visual aids in their Powerpoint or Google slides. Post intervention, it is evident that most of the students are now able to create engaging slides to help them during their presentation, with 20 students rating their response as either '4' or '5'.

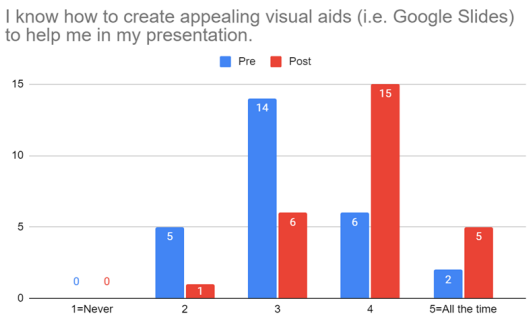


Figure 11. Creating visual aids

Besides the results obtained from the main modules related to study skills and executive functioning skills, it is also useful to understand the perception and preference of students when it comes to e-learning and online learning delivery and instructions.

RQ3: What is the effect of the iStudySmart™ online programme on the motivation and independence level of students with learning differences?

After the period of intervention, parents were invited to write testimonials. As displayed in Table 4 above, most of the parents indicated that there is an overall improvement seen in their children after the intervention. Similar to the findings from the pre- and post-questionnaires from the previous section, most of them have improved in their confidence, independence levels, stress management as well as time management and prioritisation, planning and organisation, research skills and presentation skills.
Likewise, similar to the findings, a parent had also indicated in her feedback after the intervention that while her son is able to cope with ITE, he is still finding it hard to plan in advance and rushes to complete his assignments at the last minute.

Table 4. Parent testimonials received after the intervention

Testimonials from Parents (Qualitative)
Thank you very much for your coaching and guidance provided to my son. Indeed, we are very comforted to have witnessed his progress and his confidence to present. This is in fact the first time we saw his sharing on this topic. We are very grateful for your care and guidance provided to him that has helped shape his frame of thoughts during the presentation stage and has helped him improve on his presentation skills. We believe that this platform has provided a great opportunity and exposure to learn and help boost the confidence level of an individual. We are glad that he has enrolled in this class and so fortunate to have you as his mentor. Thanks so much!
I do believe the programme has helped my daughter be more focused in searching for information [for her] research. A tool that is definitely useful in her studies now. I'm just so glad we've decided to let her join iStudySmart™. She has truly benefited a lot.
[We are] very grateful for your help in building confidence in [our daughter]. She has definitely improved in speaking more confidently.
The programme has really helped my son with his presentation skills and in planning his study schedule. The guidance from the DAS teacher also improved his communication skills with his HIL instructors. These are really useful skills in [IHL], enabling the student to be an independent learner.
I wish we had known about this programme much earlier. The title of the programme speaks for itself. iStudySmart™ has equipped my daughter with the skills and tools to manage her time better, prioritise and break down tasks into manageable ones as well as tools to plan and organise. This has helped with reducing and coping with stress. At the end of the course, the students were guided to apply their research, writing and presentation skills taught on the programme. *The programme has not only equipped my daughter with the skills but also built her confidence through the patience, understanding and encouragement received from her facilitator.*
From what I can see, [although he can keep up with the work in ITE], he usually waits till the last minute to do his assignments. There is no change.

Several other observations were provided by the teachers especially in the areas of motivation and independence after having supported and guided the students throughout the course of the programme.

Firstly, the level of progress is dependent on the student's self-motivation, independence and ownership given that iStudySmart™ is an online learning programme comprising e-learning and online consultation sessions. This means that e-learning may not be suitable for some of the students especially those with more complex learning profiles and challenged needs who require close supervision and reminders from the teachers to access their e-learning materials and complete their assignments.

Secondly, the students come from different schools and IHL institutions with varied learning needs and profiles. From interactions, experience and observations by the teachers, students with more severe learning challenges and co-morbidities tend to require more support, guidance and scaffolding. Working closely with parents and gaining their support also plays an integral part in the students' learning process and progress; from making sure their child accesses and completes their online modules and assignments promptly, to ensuring they turn up on time for their scheduled online consultation sessions.

RQ4: What is the effect of the iStudySmart™ online programme on the perceptions of online learning of students with learning differences?

Preferred mode of learning

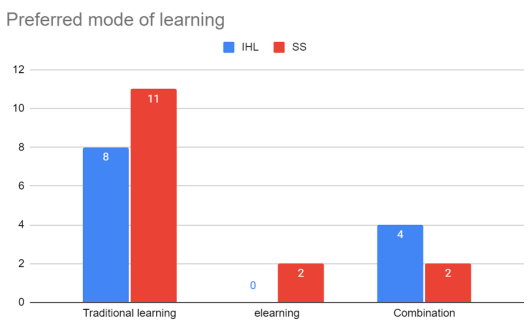


Figure 12. Experience with online (e-learning) delivery

From the figure above, the majority of students, 21 out of 27 students, have experienced e-learning as a result of the need to pivot online at the height of the COVID-19 pandemic in 2021. The IHL and Upper Secondary students were already quite familiar with the Student Learning Space (SLS) and Blackboard respectively as these e-learning platforms were used in schools to access materials, content and assignments virtually.

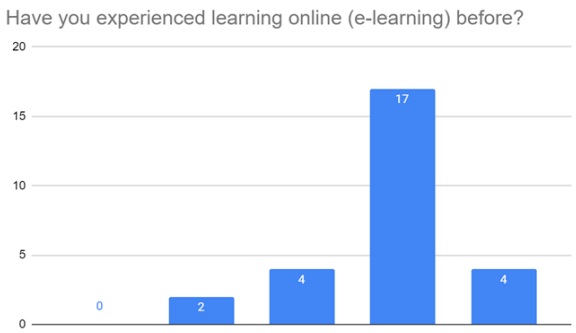


Figure 13. Preferred mode of learning

However, when it came to indicating their preference, most of the IHL and Upper Secondary students chose traditional learning over e-learning or combined learning as their preferred mode of learning. Some of the reasons cited include:

- the familiarity and assurance having the teachers in class to guide and encourage them
- the increased interaction and engagement with teachers and classmates in a face-to-face learning environment
- the instability of internet connectivity which may disrupt the e-learning experience

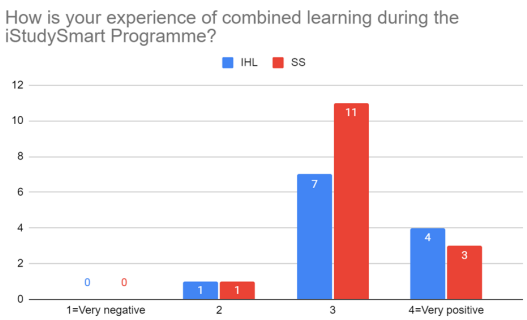


Figure 14. Experience with combined learning in iStudySmart™

While most students preferred traditional teaching over e-learning or online learning as shown in Figure 13, it is interesting to note that most of the students rated their e-learning and online learning experience on iStudySmart™ as very positive after the completion of the programme as seen in Figure 14. Some of the reasons that have contributed to a positive learning experience for the students in spite of the lessons being delivered virtually are shown in table 5.

Table 5. Reasons for liking combined learning

What do you like about combined learning (e-learning and online learning)?	**IHL**	**SS**	**Overall**
I get to learn on my own most times and interact with my friends and teachers on other times	6	7	13
I get to rotate between self-paced online learning and online instruction and guidance provided by my teacher.	5	6	11
I can learn at my own pace most times, reducing my stress and anxiety.	8	10	**18**
I get to learn through a variety of activities using many different learning styles.	**9**	10	**19**
I prefer that most instruction is delivered online, with the teacher providing support in small-group settings.	4	**11**	15
I like that it offers flexible time frames that can be personalised to my own schedule.	7	10	**17**

Most of the students felt that the combination enabled them to learn through a variety of learning methods to meet their preferred learning styles. Most of them also appreciated that the mode of learning was flexible and they were able to learn at a pace which accommodated their needs and schedule thereby, reducing their stress levels. Furthermore, some students mentioned that the user interface such as the online instructions and the e-learning materials were presented in a way that has helped them better understand the lessons.

It is interesting to note though that from the students' responses, most of the IHL students felt that learning through a variety of activities to cater to their learning needs was a factor that was important in their learning. On the other hand, most of the Upper Secondary students had indicated that learning through a teacher in a small-group setting was preferred. This may be because the latter group is not as exposed or used to a flipped approach or e-learning and, hence, preferred to have a teacher guide them instead.

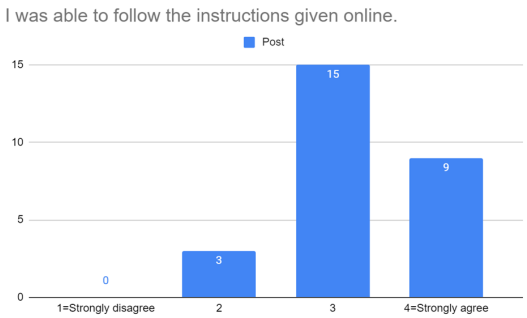


Figure 15. Students' ability to follow instructions online

Most of the students have also indicated that they were able to follow the lessons as they felt the instructions provided online were clear, straightforward and easy to follow. The positive responses might also be due to the teacher support received which was critical in enabling a positive and enriching learning experience. Students were also able to reach out to their teachers to seek support, guidance and clarification whenever they encountered any challenges in their learning

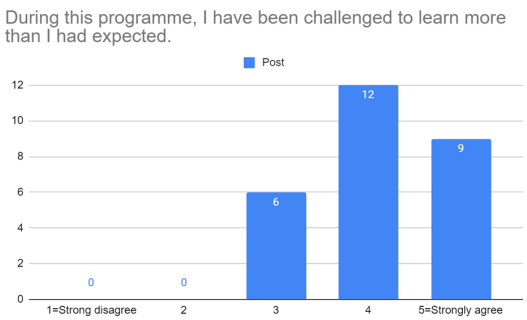


Figure 16. Students' responses on whether they have been challenged to learn more

Lastly, most of the students also shared that they were challenged to learn beyond what they had expected, prior to receiving support. Out of the 27 students, 21 of them have either rated 'strongly agree' or 'agree'. This suggests that the majority of students have learnt and acquired more knowledge and skills than they had expected prior to joining the programme.

DISCUSSION

Most of the students showed improvements after receiving support on the iStudySmart™ programme over a duration of six months especially in the acquisition of skills in

planning and organisation, tertiary writing and presentation domains where a statistical difference was found. The effect sizes also ranged from moderate to large.
While the effect size calculated for selected questions under time management and prioritisation is small, the 6 months post interview responses demonstrated positive impact as the skills acquired helped the students cope better with the increase in rigour and workload in higher learning.

Upper secondary school students and tertiary students have also positively reviewed the programme, acknowledging that they are better equipped with skills and techniques to confidently overcome challenges they may experience in their higher education studies. The post interview responses, testimonials and feedback received from students, parents and facilitators have also been very encouraging as observations have indicated that they have seen positive development in their children and cited the increase in confidence, research and presentation skills, organisation and time management as some of the benefits gained from the intervention.

Some parents have indicated that although there has been progress observed in the acquisition and applications of skills from the executive functioning and study skills categories, it is noteworthy that most of these skills need to be practised and applied across the different domains consistently and over time. Hence, it may take a while for significant progress to be demonstrated by the students. Besides, iStudySmart™ is a six-months, two term programme, and therefore, more notable gains could potentially be observed over a longer duration of intervention.

Finally, preliminary discussions also suggest that a lack of opportunities to demonstrate and practice the taught skills in school, and a limited meta-awareness of their own skills may influence the rate of progress. However, no firm conclusion can be drawn due to the relatively small student numbers. Therefore, it is important to continue reviewing and monitoring the trends and observations with incoming batches of students.

LIMITATIONS AND FUTURE RESEARCH

Despite the best intentions, this research, however, is subject to several limitations. First of all, the sample size of the participants used to evaluate this study is small. Consequently, statistical tests may not be able to identify important relationships within a particular data set. The findings and analysis, therefore, cannot be generalised to a large population, although it is a step towards understanding the challenges and barriers faced by students with dyslexia and other SpLDs in higher education in Singapore.

Secondly, there was no control group involved in the study; only an experimental group that consists of Upper Secondary and Tertiary students enrolled in the iStudySmart™ programme. Hence, a comparison between the two groups was not established in order

to examine if the effect and gains observed is due to the intervention provided and not other extraneous variables.

Next, two out of the three researchers are also the teachers and the creators of the iStudySmart™ programme which may inevitably account for some biases. Further, while there is a set of curriculum, teaching principles and pedagogical approaches to guide the teachers, the differing levels of expertise, teaching styles and experience may also result in some degree of difference between researchers.

Lastly, the student participants have varied learning profiles and needs. Those who require more support and guidance from the teachers were given more than the stipulated number of online consultation sessions. Such accommodations may affect not only the research design but also the responses provided by the students in the post-survey. Further, the students were asked to complete both the pre- and post-surveys independently. While this practice is recommended in order to eliminate any biases, the students who have learning challenges may encounter difficulties reading or understanding some of the survey items. In view of them not being able to seek clarification from the teachers, their responses, therefore, may not be a true representation of their actual learning experience.

In order to counter some of the limitations presented above, the following may be explored in future studies. Firstly, the iStudySmart™ programme could be conducted on a larger sample size to better evaluate the benefits of the intervention and draw more meaningful conclusions. In addition, as most of the skills covered would need to be practised, applied and developed over time, perhaps a longer intervention duration in future runs of the programme can be considered. Moreover, a controlled study, where controls were only involved in pre- and post-questionnaires and not intervention, should also be considered.

Finally, enhancements made to the programme and curriculum can also be looked into, to possibly include other relevant and important skills such as note-taking and critical thinking that are also crucial in helping students especially those with learning differences cope and navigate challenges encountered in higher education.

CONCLUSION

A short-term intervention demonstrated that both Upper Secondary and Tertiary students could improve their study and executive function skills effectively, with an online and e-learning delivery model designed to address these learning needs. Significant improvements were made in a range of skills, in a study which demonstrates the relevance of these skills for future success. If these results can be replicated in future studies, they can play an important role in preparing students with learning differences for higher education and the workplace.

REFERENCES

Al-Hilawani, Y. (2016). Metacognition in Real Life Situations and Study Skills and Habits: Two Types of Processes. *International Journal of Progressive Education, 12*(1), 73-89.

Al-Otaibi, W. H. (2017). The Effectiveness of Blackboard-Based Blended Teaching in the Development of Academic Achievement, Study Skills and Self-Confidence among Students of Princess Nourah bint Abdulrahman University. *International Education Studies, 10*(11), 100-115.

Alpat, M. F. (2019). *The effect of flipped learning-supported critical thinking instruction on the critical disposition and L2 writing skills* (Yüksek Lisans Tezi). İstanbul Sabahattin Zaim Üniversitesi Sosyal Bilimler Enstitüsü.

Andreou, E. & Vlachos, F. (2013). Learning styles of typical readers and dyslexic adolescents. *Journal of Visual Literacy, 32* (2), 1-14.

Ardila, A. (2008). On the evolutionary origins of executive functions. *Brain and cognition, 68*(1), 92-99. http://dx.doi.org/10.1016/j.bandc.2008.03.003

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin, 121*, 65–94.

Best, J. R., Miller, P. H., & Jones, L. L. (2009). Executive functions after age 5: Changes and correlates. *Developmental Review, 29,* 180–200.

Brosnan, M., Demetre, J., Hamill, S., Robson, K., Shepherd, H., & Cody, G. (2002). Executive functioning in adults and children with developmental dyslexia. *Neuropsychologia, 40*(12), 2144-2155.

Brown, H. D. (2001). *Teaching by Principles: An Interactive Approach to Language Pedagogy*. New York: Longman.

Carlisle, D. (2022). See me, hear me: Successes and challenges of students with invisible disabilities at university in Singapore. *Asia Pacific Journal of Developmental Differences, 9* (1), 119-142.

Carter, C., & Sellman, E. (2013). A View of Dyslexia in Context: Implications for Understanding Differences in Essay Writing Experience Amongst Higher Education Students Identified as Dyslexic. *Dyslexia, 19*(3), 149-164. doi:10.1002/dys.1457.

Casini, L., Pech-Georgel, C., & Ziegler, J. C. (2018). It's about time: revisiting temporal processing deficits in dyslexia. *Developmental Science, 21*(2), e12530.

Cheng, S. C., Hwang, G. J., & Lai, C. L. (2020). Critical research advancements of flipped learning: a review of the top 100 highly cited papers. *Interactive Learning Environments, 30*, (9)1751-1767.

Cho, M., & Tobias, S. (2016). Should instructors require discussion in online courses? Effects of online discussion on community of inquiry, learner time, satisfaction, and achievement. *International Review of Research in Open and Distributed Learning, 17*(2), 123-140.

Chou, C. P., Chen, K. W., & Hung, C. J. (2021). A Study on Flipped Learning Concerning Learning Motivation and Learning Attitude in Language Learning. *Frontiers in Psychology, 12,* 1-5 https://doi.org/10.3389/fpsyg.2021.753463.

Coffield, F., Moseley, D., Hall, E., & Ecclestone, K. (2004). *Learning styles and pedagogy in post-16 learning: A systematic and critical review.* London: Learning and Skills Research Centre.

Cohen, J. (1988) *Statistical Power Analysis for the Behavioral Sciences*. Hillsdale, NJ: Lawrence Erlbaum Associates. ISBN 978-1-134-74270-7.

Compton, D. L., Fuchs, L. S., Fuchs, D., Lambert, W., & Hamlett, C. (2012). The cognitive and academic profiles of reading and mathematics learning disabilities. *Journal of Learning Disabilities, 45*, 79–95. http://dx.doi.org/10.1177/0022219410393012

Dahan, O., Hadas Lidor, N., Meltzer, Y., & Roitman, Y. (2008). Organizing recourses and time – from theory to practice, workshop in the framework of the center for supporting students with learning disabilities. *Topics in Special Education and Rehabilitation, 3,* 59–75 (In Hebrew).

Dawson, P., & Guare, R. (2004). *Executive skills in children and adolescents: A practical guide to assessment and intervention.* New York: Guilford Press.

Dobson Waters, S., & Torgerson, C. J. (2021). Dyslexia in higher education: a systematic review of interventions used to promote learning. *Journal of Further and Higher Education, 45*(2), 226-256.

Durkin, K., & Main, A. (2002). Discipline-based study skills support for first-year undergraduate students. *Active Learning in Higher Education, 3*(1), 24-39. http://dx.doi.org/10.1177/1469787402003001003

Dyslexia Association of Singapore. (2019). *What is dyslexia?.* Retrieved September 25, 2020 from https://www.das.org.sg/about-dyslexia/what-is-dyslexia/what-is-dyslexia.html#myths-about-dyslexia

Employability Skills. (2008). *Time Management Questionnaire*. https://www.scribd.com/doc/7478848/Time-Management-Questionnaire.

European Dyslexia Association. (n.d.). *What is dyslexia?* Retrieved December 28, 2022, from https://eda-info.eu/what-is-dyslexia/

Fleming, A. P., & McMahon, R. G. (2012). Developmental context and treatment principles for ADHD among college students. *Clinical Child Family Psychological Review, 15*, 303–329. http://dx.doi.org/10.1007/s10567-012-0121-z

Foreman, S. (2017). *The LMS guidebook: Learning management systems demystified*. American Society for Training and Development.

Gallardo, M., Heiser, S., & Arias McLaughlin, X. (2015). Modern languages and Specific Learning Difficulties (SpLD): implications of teaching adult learners with dyslexia in distance learning. Open Learning: *The Journal of Open, Distance and e-Learning, 30*(1), 53-72.

Gillingham, A., & Stillman, B. W. (1997). *The Gillingham manual*. Cambridge, MA: Educators.

Grasha, A. F. (1996). *Teaching with style*. Pittsburgh, PA: Alliance.

Gray, J. A., & Diloreto, M. (2016). The Effects of Student Engagement, Student Satisfaction, and Perceived Learning in Online Learning Environments. *International Journal of Educational Leadership Preparation, 11*(1).

Griffin, E. & Pollak, D. (2009). Student experiences of neurodiversity in higher education: insights from the BRAINHE project. *Dyslexia, 15*(1), 2341.

Hatcher, J., Snowling, M. J., & Griffiths, Y. M. (2002). Cognitive assessment of dyslexic students in higher education. *British journal of educational psychology, 72*(1), 119-133.

Heiman, T., & Precel, K. (2003). Students with Learning Disabilities in higher education: Academic strategies profile. *Journal of Learning Disabilities, 36*, 248–258.

Hewes, D. G. (2020). Entrepreneurs with dyslexia in Singapore: The incidence, their educational experiences, and their unique attributes. *Asia Pacific Journal of Developmental Differences, 7*(2), 157-198.

Higgins-Opitz, S. B. & Tufts, M. (2010). Student perceptions of the use of presentations as a method of learning endocrine and gastrointestinal pathophysiology. *Advanced Physiology Education, 34*, 75–85.

Higher Education Funding Council for England. (2015). *Support for Higher Education Students with Specific Learning Difficulties.* York Consultancy and University of Leeds.

Horowitz-Kraus, T. (2014). Pinpointing the deficit in executive functions in adolescents with dyslexia performing the Wisconsin card sorting test: An ERP study. *Journal of Learning Disabilities, 47,* 208–223. http://dx.doi.org/10.1177/0022219412453084

Hoover, J. J. (1989). Study skills. In E. A. Polloway, J. R. Patton, J. S. Payne, & R. A. Payne (Eds.), *Strategies for teaching learners with special needs* (4th ed.), 362-377). New York: Macmillan.

Hunt, S. K., Simonds, C. J., & Simonds, B. K. (2009). Uniquely qualified, distinctively competent: Delivering 21st century skills in the basic course. *Basic Communication Course Annual, 21* (1), 6.

Jones, C. H., Slate, J. R., & Kyle, A. (1992). Study skills of teacher education students. *The Teacher Educator, 28* (1), 7-15.

Kaufman, D. (2004). Constructivist Issues in Language Learning and Teaching. *Annual Review of Applied Linguistics, 24*: 303-319.

Kirby, J. R., Silvestri, R., Allingham, B. H., Parrila, R., & La Fave, C. B. (2008). Learning strategies and study approaches of postsecondary students with dyslexia. *Journal of Learning Disabilities, 41*(1), 85–96.

Ladd, P. D., & Ruby, R. (1999). Learning style and adjustment issues of international students. *Journal of Education for Business, 74*, 363–367.

Learning Disabilities Association of Minnesota. (n.d.). *What are some characteristics of LD in Adults?* https://www.dhs.state.mn.us/main/groups/agencywide/documents/defaultcolumns/dhs-291025.pdf

MacCullagh, L., Bosanquet, A., & Badcock, N. A. (2017). University students with dyslexia: A qualitative exploratory study of learning practices, challenges and strategies. *Dyslexia, 23,* 3–23. doi:10.1002/dys.1544

Marsh, R. L., & Hicks, J. L. (1998). Event-based prospective memory and executive control of working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24*(2), 336-349.

Martín-Rodríguez, Ó., Fernández-Molina, J. C., Montero-Alonso, M. Á., and González-Gómez, F. (2015). The main components of satisfaction with e-learning. *Technology, Pedagogy and Education, 24*(2), 267–277.

Ministry of Education, Singapore. (2021, August 13). *Special educational needs support at Institutes of Higher Learning.* https://www.moe.gov.sg/special-educational-needs/school-support/ihl

Miranda, E. L., Doong, M. F., Llanos, N., Llagas, E. G., Diacor, R., & Dalion, S. K. (2022). Study skills and academic performance of college students in the new normal environment. *Southeast Asian Journal of Multidisciplinary Studies, 1*(2).

Moore, R. (2014). Importance of developing community in distance education courses. TechTrends *58*(2), 20-25.

Mortimore, T. (2005). Dyslexia and learning style – a note of caution. *British Journal of Special Education, 32*, 145-148.

Mortimore, T., & Crozier, W. (2006). Dyslexia and difficulties with study skills in higher education. *Studies in Higher Education, 31*, 235–251. doi:10.1080/03075070600572173

Müller, U., Lieberman, D., Frye, D., & Zelazo, P. D. (2008). Executive function, school readiness, and school achievement. In S. K. Thurman, & C. A. Fiorello (Eds.), *Applied Cognitive Research in K-3 Classrooms,* 41–84. New York: Routledge.

Nash, G., Crimmins, G., & Oprescu,F. (2016). "If First-year Students are Afraid of Public Speaking Assessments What Can Teachers Do to Alleviate Such Anxiety?" *Assessment & Evaluation in Higher Education 41* (4): 586–600. doi:https://doi.org/10.1080/02602938.2015.1032212.

Nicolson, R. I., & Fawcett, A. J. (1990). Automaticity: A new framework for dyslexia research. *Cognition, 35*, 159-182.

Nicolson, R. I., Fawcett, A. J., & Dean, P. (1995). Time estimation deficits in developmental dyslexia: evidence of cerebellar involvement. *Proceedings of the Royal Society of London. Series B: Biological Sciences, 259*(1354), 43-47.

Nortvig, A. M., Petersen, A. K., & Balle, S. H. (2018). A Literature Review of the Factors Influencing E-Learning and Blended Learning in Relation to Learning Outcome, Student Satisfaction and Engagement. *Electronic Journal of E-learning, 16*(1), 46-55.

Nouri, J. (2016). The flipped classroom: for active, effective and increased learning–especially for low achievers. *International Journal of Educational Technology in Higher Education, 13*(1), 1 -10.

Office for Students. (2017). *"Beyond the Bare Minimum: Are Universities and Colleges Doing Enough for Disabled Students?"* https://www.officeforstudents.org.uk/publications/beyond-the-bareminimum-are-universities-and-colleges-doing-enough-for-disabled-students/#participation

Olofsson, Å., Ahl, A., & Taube, K. (2012). Learning and study strategies in university students with dyslexia: Implications for teaching. *Procedia Social and Behavioural Sciences, 47*, 1184–1193. doi:10.1016/j.sbspro.2012.06.798.

Olofsson, Å., Taube, K., & Ahl, A. (2015). Academic achievement of university students with dyslexia. *Dyslexia, 21*(4), 338-349. doi:10.1002/dys.1517

Pino, M., & Mortari, L. (2014). The inclusion of students with dyslexia in higher education: A systematic review using narrative synthesis. *Dyslexia, 20*, 346–369. doi:10.1002/dys.1484

Proctor, B. E., Prevatt, F. F., Adams, K. S. Reaser, A., & Petscher, Y. (2006). Study Skills Profiles of Normal-Achieving and Academically-Struggling College Students. *Journal of College Student Development, 47*(1), 37-51.

Quick, R. L. (2013). Exploring faculty perceptions toward working with academically vulnerable college students. *College Quarterly, 16*(4), n4.

Ramus, F., Rosen, S., Dakin, S. C., Day, B. L., Castellote, J. M., White, S. & Frith, U. (2003). Theories of developmental dyslexia: insights from a multiple case study of dyslexic adults. *Brain, 126*, 841865.

Rasskazova, T., Muzafarova, A., Daminova, J., & Okhotnikova, A. (2017). Challenges of teaching a blended English course to university students. *International Scientific Conference eLearning and Software for Education (3),* 303. "Carol I" National Defence University.

Reaser, A., Prevatt, F., Petscher, Y., & Proctor, B. (2007). The learning and study strategies of college students with ADHD. *Psychology in the School, 44*(6), 627-638.

Research Collaboration. (2015). *Self-Efficacy Formative Questionnaire Technical Report.* http://www.researchcollaboration.org/uploads/Self-EfficacyQuestionnaireInfo.pdf.

Rose, J. (2009). *Identifying and Teaching Children and Young People with Dyslexia and Literacy Difficulties*. Nottingham: DCSF Publications.

Rosenblum, S. (2012). Reliability and validity of the time organization and participation scale (TOPS). *Neuropsychological Rehabilitation, 22*, 65–84.

Rowan, L. (2014). University transition experiences of four students with dyslexia in New Zealand. *Australian Journal of Learning Difficulties, 19*(2), 129-136. doi:10.1080/19404158.2014.923478

Smith-Spark, J. H., Fawcett, A. J., Nicolson, R. I., & Fisk, J. (2004) .Dyslexic students have more everyday cognitive lapses. *Memory, 12* (2), 174-182

Southard, S., Meddaugh, J., & France-Harris, A. (2015). Can SPOC (self-paced online course) live long and prosper? A comparison study of a new species of online course delivery. *Online Journal of Distance Learning Administration, 18*(2), 8.

Sparks, R. L., & Lovett, B. J. (2009). College students with learning disability diagnoses: Who are they and how do they perform? *Journal of Learning Disability, 42,* 494–510. http://dx.doi.org/10.1177/0022219409338746

Swan, K., & Shih, L. F. (2005). On the nature and development of social presence in online course discussions. *Journal of Asynchronous learning networks, 9*(3), 115-136.

Tomlinson, C. A., Brighton, C., Hertberg, H., Callahan, C. M., Moon, T. R., Brimijoin, K., & Reynolds, T. (2003). Differentiating instruction in response to student readiness, interest, and learning profile in academically diverse classrooms: A review of literature. *Journal for the Education of the Gifted, 27*(2-3), 119-145.

Trainin, G., & Swanson, L. H. (2005). Cognition, metacognition and achievement of college student with learning disabilities. *Learning Disability Quarterly, 28*, 261–272.

U.S. Department of Education. (2006). *Assistance to States for the education of children with disabilities and preschool grants for children with disabilities; Final rule.* Individuals with disabilities education act (IDEA) http://idea.ed.gov/download/finalregulations.pdf

Varvara, P., Varuzza, C., Sorrentino, A. C. P., Vicari, S., & Menghini, D. (2014). Executive functions in developmental dyslexia. *Frontiers in Human Neuroscience, 8*, 1–8.

West, T. G. (2014). Amazing Shortcomings, Amazing Strengths – Beginning to Understand the Hidden Talents of Dyslexics, *Asia Pacific Journal of Developmental Differences, 1*(1) pp. 78-89.

MATHS PROGRAMME

DYSLEXIA ASSOCIATION OF SINGAPORE

Specialised Educational Services
UNLOCKING POTENTIAL

The SES Maths Programme aims to effectively support students with dyslexia who have persistent difficulties in mathematics, particularly with understanding of math concepts and word problems.

HOW DOES DYSLEXIA AFFECT MATHS?

- Understanding Maths concepts
- Reading or understanding Maths problems
- Understanding mathematical relationships
- Recalling mathematics facts such as the times tables
- Following the sequence of events in word problems
- Completing problems with multi-step calculations

The Maths Programme currently offers 3 curricula:

ESSENTIAL MATHS

Developed to help students who are struggling to cope with Maths at the school level

- Conceptual Understanding
- Procedural Proficiency
- Reading Comprehension
- Mathematical Communication

PROBLEM SUMS FOR UPPER PRIMARY (STP)

Developed to help Primary 5 / Primary 6 students who are strong in math concepts, but continue to show difficulties with understanding and solving word problems

- Challenging Word Problem Types
- Thinking Skills & Heuristics
- Mathematical Communication
- Reading Comprehension

SEC 1 NORMAL TECHNICAL MATHS (STP)

Developed to help Secondary 1 students taking the Normal Technical Maths syllabus in their transition to secondary school mathematics

- Conceptual Understanding
- Procedural Proficiency
- Thinking Skills & Mathematical Communication
- Real-Life Applications

FOR MORE INFORMATION, VISIT WWW.DAS.ORG.SG

6444 5700
info@das.org.sg
@dyslexiasg

Asia Pacific Journal of Developmental Differences
Vol. 10, No. 1, January 2023, pp. 99—118
DOI: 10.3850/S2345734123000491

Examining the Applications of Educational Technologies in Teaching and Learning Practices in a specialist intervention setting

Stephanie Ong[1], Nithyashree Murthy[1] and Soofrina Binte Mubarak[1*]

1. Dyslexia Association of Singapore

Abstract

The use of technology in the classroom nowadays is widespread and seen by both students and teachers internationally as almost essential. Research indicates that students, particularly today, prefer technology because they think it improves their learning. Their views also include how the use of digital tools appears to improve the effectiveness of their learning. The question arises, do educators on the other hand complement the teaching with sufficient educational technologies? This study will look into two goals which have implications for the use of technology across the world, focusing on implementation in Singapore to provide a case study of improved effectiveness. Firstly, it will start by examining how educational therapists at the Dyslexia Association of Singapore Limited have adopted Educational Technology (EduTech) in their specialist intervention classes. Secondly, it will examine the usefulness of EduTech in teaching and learning. The Technology Adoption Paradigm (TAM), the most popular and scientifically supported model for technology acceptance, serves as the foundation for this research study's investigation of these goals. The findings have implications internationally for educational organisations incorporating technology into their teaching and learning.

Keywords: Educational technology, Online teaching, COVID-19, Teachers' attitudes, Self-efficacy, Special education, Specialist intervention, Dyslexia, Remote teaching

** Correspondence to:*
Soofrina Binte Mubarak, Senior Educational Therapist and EduTech Coordinator, Dyslexia Association of Singapore.
Email: Soofrina@das.org.sg

INTRODUCTION

Technology has cemented its presence in our lives for many years and particularly in this century. Technology is constantly present in many aspects of our daily lives and plays a very important role. Raja & Nagasubramani (2018) also further assert that "the impact of technology can be felt in every possible field and one such field is Education."

In today's educational landscape, the use of technology is prevalent and considered almost essential to students and teachers. Especially in this modern era, students prefer technology as they believe that it has an impact on their learning. Their beliefs extend to how the incorporation of technology tools seems to have an increased effectiveness to their learning (Raja & Nagasubramani, 2018). Ritchie & Wiburg (1994) also mention that "technology's greatest power may be the way in which its use causes teachers, administrators, and students to rethink teaching and learning" (p. 152).

In 2020, the COVID-19 pandemic shook the world "which forced the sudden closure of schools and the directive to work from home" (Goodsall, 2021). Adaptation was mandatory especially in the field of education and this called upon an immediate change for schools to move lessons online and have both teachers and students adapt to new styles of delivering lessons and studying. "Thanks to technology; education has gone from passive and reactive to interactive and aggressive", (Raja & Nagasubramani, 2018)

This sudden change has proved overwhelming for teachers. They have not had time to accept and embrace the change. Usually, such paradigm changes in any field happens over a period of time with a lot of experimentation and analysis of what works and what needs to be tweaked. Unfortunately, COVID-19 did not give us that opportunity due to the sudden closure of schools and the need for alternate modes of education. Trying to replicate physical lessons in an online situation is a major change in the way teaching is done. As Milman (2020) notes, "Educators suddenly thrust into emergency remote teaching do not have ideal conditions to offer well-planned, quality instruction."
This change was equally overwhelming for students also. The boundaries between school and home blurred and the lack of socialisation and community also had a major impact on the motivation and engagement levels of students. This sudden transition to online learning could possibly lead to a deficit in learning for students, according to (Winter et al., 2021). These deficits in learning will have more of an impact on the disadvantaged learners as they face more barriers when it comes to online learning (Willis, 2020).

The prevalence of technology has undoubtedly helped to contribute to the possibility of shifting classes online almost instantaneously. This stands true even within special education classrooms in Singapore. Within the Dyslexia Association of Singapore Limited,

Educational Therapists (EdTs) have also followed suit and turned towards virtual learning when the directive was given for a nationwide lockdown.

AIM OF STUDY

As our team began this study, we set out to investigate an objective. We will be looking at the adoption of educational technology (EduTech) by educational therapists in the Dyslexia Association of Singapore Limited. This research study also incorporates the Technology Acceptance Model (TAM), the most influential and empirically validated model for technology acceptance, as its basis for exploring these items.

Technology Acceptance Model

Davis (1986) proposed the Technology Acceptance Model (TAM) to foresee user acceptance of any given technology by adapting the Theory of Reasoned Action (Fishbein & Ajzen, 1975). (See Figure 1). Davis (1986) asserts that a user's Intention to Use is the most important determinant of his or her ultimate use of a technology. However, it is hypothesized that such intention is positively influenced by a user's overall attitude toward using technology. This attitude is influenced by two beliefs: perceived usefulness and perceived ease of use.

Perceived Usefulness is defined as "the degree to which a person believes that using a specific system would improve his or her job performance," whereas Perceived Ease of Use is defined as "the degree to which a person believes that using a specific system would be free of effort" (Davis, 1989, p. 320).

Perceived Usefulness has a direct impact on attitude toward using a technology and behavioural intention to use the technology, whereas Perceived Ease of Use has an indirect impact on attitude toward technology use and behavioural intention to use a technology. Similarly, external variables such as objective system design characteristics

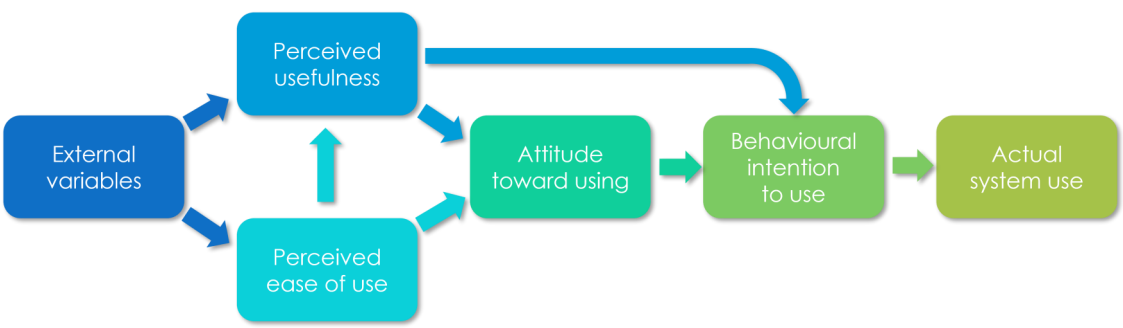


Figure 1. Technology acceptance model (Davis, 1989)

and learners' self-efficacy in using technology are hypothesized to have a direct influence on both beliefs (Davis, 1986).

When it comes to context-based understanding of the usage of a specific technology, TAM only provides general information about whether users are willing to accept a technology (Liu et al., 2010; Padilla-Meléndez et al., 2013).

Despite these limitations, TAM has been shown to be one of the most effective models for examining users' technology acceptance and usage behaviour (Grani & Maranguni, 2019). Researchers have increasingly used the Model to predict learners' acceptance of technology-assisted learning (Al-Emran et al., 2018). These studies expand and modify TAM's initial constructs by incorporating various variables that fall primarily into two categories: external variables and perceived variables.

RESEARCH DESIGN AND METHODOLOGY

For this study, we conducted a survey with educational therapists (EdTs) from the Dyslexia Association of Singapore Limited (DAS). EdTs are trained to work with children primarily with dyslexia and/or with comorbidities. The age group of these children ranges from 7 years old to 16 years old. The EdTs are trained to teach using the Orton-Gillingham approach and have been trained to integrate tech tools in their lessons. The EdTs have been using these methods to teach at least a year prior to the study.

The data was collected over 2 phases. Phase 1 consisted of interviews with 8 EdTs. Phase 2 consisted of a survey with 50 EdTs. The questions for the survey were derived after analysing the interview responses of the 8 EdTs.

Phase One of Study

Participants

In Phase One, 8 participants out of 50 were interviewed on their personal views on how their technology usage is like on a regular basis. Within this group of participants, we have a range of educational therapists with varying levels of teaching experience. In the first round, 8 Educational Therapists participated in online interviews. They were spread across a varied age group from mid-twenties (37.5% - 3 female) to early thirties (37.5% - 2 female and 1 male) and early fifties (25% -1 male and 1 female). The students they teach range from the ages of 7 to 16 with the focus being on literacy. Two of the Educational Therapists also teach Mathematics for the students aged between 6 and 13. 25% of the teachers have more than 15 years of teaching experience, 50% of the teachers have between 5-7 years of experience and 25% of the Educational Therapists have between 3-5 of teaching experience.

All the 8 Educational Therapists have a laptop and at least 3 iPads for students' use. 50% of the Educational Therapists would fall under the high usage category (using some form of technological tools at least eight times a week), 25% would fall under the medium usage category (usage of technological tools at least 5 times a week) and 25% would fall under the low usage category (usage of technological tools at least 2 times a week).

Measures

Phase 1 of data collection consisted of semi-structured, face-to-face interviews with 8 EdTs. The participants were interviewed on the following variables. Attitudes (attitudes towards EduTech), Self-efficacy (self-confidence in using EduTech), Usage (what influences EduTech use in their classrooms, effectiveness of EduTech and how is it implemented), Experiences (current experiences with EduTech, and suggestions on future EduTech use), Pedagogy (EDT's teaching approaches & EduTech tools used in teaching practices), Perceived environmental support (from both organisation and colleagues) and Perceived student learning outcomes.

Procedure

The interviews were conducted online through Microsoft Teams over a period of 10 days. Each interview lasted for an hour and the questions were open ended.

Phase One Results

One of the important aspects being examined is the teacher's beliefs and attitudes One of the important aspects being examined is the teacher's beliefs and attitudes towards technology. This is important as it can be one of the major obstacles in the implementation of technology. "Second-order barriers are intrinsic to teachers and include beliefs about teaching, beliefs about computers, established classroom practices, and unwillingness to change", (Ertmer, 1999) Upon completion of the interviews and based on the research conducted, there were several key findings that surfaced from our analysis.

Overall, it was noted that there were varying degrees of acceptance towards EduTech among the participants. Those participants who were found to be from the EduTech team showed more acceptance and participation in the use of tech. However, the participants who were not from the EduTech team were observed to have more reservations when it came to accepting the use of tech. In addition, this also further contributed to the difference in the participants' general attitudes towards EduTech and how they perceived the implementation efforts of technology by DAS. In the next part of the findings, it was noted that reasons for using technology would have an impact on how the participants made their selections of Edutech tools for lessons and the kind of approach that they would undertake to implement the use of technology.

Reasons for Using Technology

Based on the data compiled from the interviews, there were a few commonly cited reasons for using EduTech among the participants. These include using tech tools for i) teaching and learning purposes, ii) implementing the use of technology to benefit their learners, iii) using technology to help improve classroom behaviours as well as iv) meeting organisational expectations and requirements.

Technology has an important role in promoting activities for learners and has a significant effect on teachers' teaching methods (Ahmadi, 2018). Our interview data analysis has also shown that the participants were generally keener on using technology when they perceived it as being helpful in enabling them to have better control in their classrooms. One participant quoted that, "Edtech is effective for my role as a teacher" and this is further elaborated by another participant who shared that, "Some of the things that we traditionally have cannot really be replaced by any tool or technology, but we can definitely enhance the learning experience through it." This demonstrates that when a teacher employs the use of technology and integrates it as part of their teaching method to support the curriculum, there are gains that extend beyond the learners and have an impact on the teachers and their lesson delivery. This contributes to a more positive outlook and attitude towards implementing technology in a classroom.

Secondly, as students possess individual learning capabilities, the use of technology has also helped to accommodate their differing abilities and contribute to their understanding and growth of learning such as reading and spelling. They have also gained a better understanding of their lessons. This is further supported by (Dawson et al, 2008) and (Gilakjani, 2014) who established that the use of technology allows the focus of learning to be centered on the learner. As shared by one of the participants, "..there are learners with different abilities in a class, for the faster learners, we can give them apps to enrich their learning while waiting for their turn." This further reinforced that the implementation of technology has helped accommodate differing learning capabilities and has provided opportunities for teachers to produce alternatives for varying learner's profiles while maintaining the interest of every learner.

Thirdly, the use of technology becomes much more convincing to the participants when they note that it has helped them to improve classroom behaviour. These behaviours may include but are not limited to the students' attention, confidence, motivation to learn and engagement. As mentioned by one of the participants, "My students are very engaged when I use PowerPoint or when videos are shown to them." Therefore, depending on the teacher's objective of the lesson, suitable tools are selected. For example, some participants shared they used games or online mind maps to enhance their lesson and improve interaction.

Lastly, setting organisational expectations and requirements of using technology creates a culture and an environment within DAS where teachers are encouraged to use technology. This directly contributes to and opens an opportunity and provides a platform for the teachers to gain access to technology and expand their knowledge on it. Some of the participants also cited environmental and organisational efforts as factors that helped support them to increase their usage of technology in class. Such efforts include conducting workshops, access to monthly newsletters on tech tips and having an iRep(trained teacher in technology) at their centre to assist and provide support that has helped them.

Selecting EduTech Tools for Lessons

Technology often allows teachers to add on another dimension to their lesson delivery. As mentioned by Bolick and Cooper (2013), "integration of technology into the classrooms is by no means an effortless process". Teachers will have to go through the process of researching suitable tools and trying each one out before introducing it into the classroom.

Based on our findings, there were a few common factors when it came to the selection of EduTech tools. These considerations include teaching purposes, learners' profiles, EdT's self-efficacy and recommendations from colleagues and organisations.

Teaching purposes refers to what an EdT aims to achieve in that lesson. If the objective of the lesson is to check on the understanding of the concept, a game format would then be chosen. Alternatively, if the objective is to introduce the topic, the teacher would then look up a video or a tool that would help in explaining the concept or in giving the student some background knowledge.

One of the other factors that is high on the list includes the availability of the tool. If the app or tool is preloaded in the tablet or computer, this easy access to it increases the chances of use by the EdT. However, the cost of the tool is also a factor. Free apps or tools tend to be more popular; however, participants cited that these apps or tools have their limitations as well, such as short free trials. This is similar to the results of the survey conducted by Winter et al. (2021) where the Irish primary and secondary teachers also felt that there were many useful tools available, and they would be used effectively by the teachers provided they were available and the teachers were trained in using them.

Learners' profiles also play an important role in the tools chosen. The age and ability of the learners are considered when choosing a tool as the aim is to make the learning interesting and interactive and not to leave the learner feeling incompetent or frustrated when it comes to tech usage. The difficulty level and length of time spent on the tool are also based on the age and ability of these learners. Some participants added that on top of these factors, another challenge within this includes learners who are not familiar

with the use of certain devices such as the iPad. Quoting a participant, "slow learners may not understand how to use the tech tools." Overall, this also adds on to the time taken to use the tool during class time.

Another factor for tool selection is the self-efficacy of the EdT. Teachers have the very important role of being the decision makers in using technology. Their views and notions on the benefits or difficulties in using a technological tool can either encourage or hamper the implementation of technological tools or platforms. As Christopoulos and Sprangers (2021) mention, the successful assimilation of any technological tool is dependant (to a large extent) on the teachers' mindset and self-belief in using that technology. The comfort and ease of usage from the EdT's point of view, along with the time taken to learn and implement will impact the choice. If EdTs are trained in using the tool, the probability of the tool being chosen are high owing to familiarity.

The last factor in the choice of tools lies in whether the organisation recommends it or whether other colleagues have successfully used the tool and have further recommended it. This again is like the findings of Winter and colleagues (2021) that teachers are leveraging the knowledge and skills of their colleagues. Participants have shared that the current efforts promoted by DAS in addition to having been supported by iReps and colleagues do help to increase their exposure and usage of the tools. However, they had also cited that the use of tools would depend on the individual's comfort level, and they felt that they were gaps in training.

Mixed Approach in Using Edutech Tools in Classrooms

Another key finding in Phase 1 was the mixed approach to the usage of tools within the classroom. In some instances, the participants controlled the usage of the tool to a certain extent. This approach is mostly dependent on the age of the student. Younger students were closely monitored in the usage of the tool, to ensure that the tool was used appropriately to maximise learning opportunities. It has also been observed that some participants preferred their students to use the tools independently to encourage self-learning while some others adopted a blended approach whereby the students had independence within a controlled or a monitored setting.

Perceived Support from Environment and Satisfaction Towards DAS Initiatives In Promoting The Use Of Edutech

To employ technology and implement it successfully, there are usually a variety of factors which influence the process. One of the important factors include the support from the environment. In the interviews, participants were asked if they felt like there was enough support to encourage them to use technology. For those participants who felt supported, they cited that having initiatives such as M-Learning Week, Appy Hour sessions and weekly sharing helped expose them to more tools. In addition, there was also support

from the Edutech team if they had queries. They also found motivation from colleagues who use tech more often and received feedback on their usage. For those who felt less supported in their environment, they cited the lack of time and insufficient training as their reasons.

Overall, it was found that those participants displaying a higher level of satisfaction were generally more enthusiastic in trying to employ the use of technology in class. They felt more motivated and positive about technology and even tried to create interest among colleagues. They tend to find more opportunities to use technology in their classrooms which led to enhanced teaching on their end.

Those who displayed a lower satisfaction level cited the lack of time, duration, and quality of training as reasons for it. The participants find that the sessions are too short and there is not enough time to explore the tools. In addition, the training was not comprehensive enough for them to be able to understand how they can use it within their lessons.

COVID-19

With the arrival of the pandemic, traditional face to face lessons had to give way to make room for technology to reduce the disruption and learning for the learners. Within DAS, lessons also moved online within a short period of time.

Teachers had to tap on their knowledge of technology to conduct lessons using online tools. Some participants shared concerns of how younger learners may struggle with using online tools as they were unfamiliar with them, and parents may not be available to provide technical support. This also applies to teachers with lower tech usage who face similar struggles. As for teachers who use technology more frequently, they have some background in technology and generally cited less anxiety as compared to their peers. Overall, most of the participants displayed greater awareness and confidence in using technological tools after having to conduct online lessons over a period of time. They also cited that the support from the Edutech team and their colleagues helped them as they were introduced to suitable tools and provided relevant support when necessary.

Hence, their experiences during the lockdown helped pave the way to integrate technology more effectively, with the use of a wider variety of tools such as online whiteboards, game platforms, quizzes, learning to edit online documents/slides etc.

While the pandemic is unfortunate, it has opened up an opportunity for the growth of our teachers in terms of increasing their knowledge in tech and enhancing classroom instruction in an innovative way.

DISCUSSION

Suggestions Based on Phase 1 Results to Improve Tech Usage at DAS

Through the research, it has been observed that there is a need to increase the number of resources for teachers and learners. In addition, DAS will also need to spend more time on training the staff to implement technology within their classrooms. Firstly, for the teachers, there is a need to increase the number of devices (iPads) for each teacher as the current number of 3 iPads per teacher is insufficient for all the learners to use in class. Teachers would also benefit from having more readily available resources and lesson materials. As for the students, for them to benefit from the use of Edutech, there is a need to install more apps on the iPads for teachers to explore and use. It will also be beneficial if laptops are made available for them to use as needed.

As for the implementation of Edutech within classrooms, teachers will benefit from higher quality training on an organisation-wide level as well as receiving enhanced support for one-to-one training. It was also proposed that we could employ online platforms for material consolidation such as Blackboard.

The 8 participants were interviewed based on their personal views on the adoption of educational technology. The results were analysed and the team identified some of the reasons based on the participants' responses to i)adopting tech in their classrooms, ii) how they make their selection for tech tools to be used in their lessons and iii) how they have implemented it in their classrooms.

One of the key findings of this survey also demonstrated that there were contrasting satisfaction levels when it came to DAS' EduTech initiatives. The EdTs who were more satisfied with DAS EduTech initiatives were more likely to incorporate EduTech in their lessons while those who were dissatisfied were less likely to incorporate EduTech. The reasons cited were a general lack of quality in terms of comprehensive training and also a lack of time to explore tech tools as their reasons.

Furthermore, the contrasting satisfaction levels were dependent on the perceived support from the environment when it came to using EduTech. Those participants who displayed positive satisfaction levels were more motivated to use EduTech and more likely to participate in the usage of Edutech. They were also generally more receptive to feedback with their usage of Edutech. These participants were generally observed to be part of the EduTech support team. However, the participants who were dissatisfied felt less supported and commonly cited the lack of time and resources to use EduTech as well as insufficient training for their perceived lack of support from the environment.

This study has helped to identify some of the areas where DAS can improve its EduTech initiatives. One of the main aspects is to continue to build and expand on the EduTech resources available to the EdTs. This includes having readily available lesson materials and making more EduTech tools accessible to EdTs and students. The second aspect is implementation of online platforms. Online platforms like Blackboard and Google Classroom are user-friendly and open opportunities for Edts to make provisions for differing student abilities. The final aspect for consideration is training the EdTs in the usage of various apps and tools. Concurrently, DAS could continue to give them opportunities and time to explore EduTech tools by providing them with videos and links of apps in usage. Another possible suggestion is to increase awareness and emphasise on the benefits of the usage of selected tools in conjunction to the lesson objectives.

CONCLUSION

In conclusion, this paper serves to understand how Edutech is currently being adopted by the EdTs within DAS. The research applies the Technology Acceptance Model (TAM) framework where it helps us to understand how individuals adopt and use technology.

Based on the results and analysis conducted by Temasek Polytechnic, we hypothesise a significant difference between the different levels of Edutech advocacy. Higher advocacy scores (i.e: higher levels of Edutech advocacy) result in increased levels of frequency, attitude, and motivation towards the use of EduTech. This may also give rise to better teaching outcomes and student learning outcomes. The success of technology in boosting student learning depended on how openly and successfully teachers accepted and incorporated it into education (Mubarak & Ram, 2016). The change-agents are teachers, not technology. In addition to this, with the advancement of technology, we should learn to progress and continue to embrace the change.

Upon conducting the survey and interviews, we noted several barriers that have an impact on the teacher's decision on whether they would choose to use tech within a classroom. The first-order barrier, a term referred to by Ertmer (1999), suggests that the first barrier to embracing tech is due to the lack of tools and training provided. As long as steps are done to acquire these tools and enough time is allocated to instruct and train teachers to incorporate them into lessons, the first barrier can be removed. However, more crucially, the key to breaking down these barriers may ultimately depend on teachers' attitudes and views about technology. In the case of DAS, tools and training have been provided. However, it is noted that the initiatives can be further improved to allow for more learning opportunities to take place. Additionally, it was noted from the interviews that despite receiving tools and training, some teachers continued to express reluctance toward using technology because of their perceptions of their own technical skills and capabilities. Therefore, it is essential to comprehend the objectives when making training plans. The training must be more extensive and effective in its teaching approaches, with a focus on boosting the confidence of those employing technology.

Furthermore, in light of the current political atmosphere, it is even more crucial that we fill in any knowledge gaps among educators about Edutech. The use of digital technology has permeated every aspect of contemporary life. People are growing comfortable with the idea of technology, and this marks a strong contrast between two different generations. Students these days are referred to as "digital natives," suggesting that they have grown up with technology while adults are frequently referred to as "digital immigrants," denoting the necessity for them to acquire new skills (Mubarak, 2017). The progress of technology will only continue to advance, and it is crucial to keep up with them as it opens endless opportunities for the teaching industry.

There is now more acceptance of the use of tech tools in classrooms, especially after our experiences with COVID. The environment has forced this change and altered the traditional modes of teaching and learning for both teachers and students alike. Currently, technology has become deeply ingrained in our educational system and has made it possible for tools and ideas to be shared internationally. The value of technology has grown exponentially within a short span of time, not only increasing awareness among people but also contributed to an increased level of the tech abilities among teachers and students. Access to learning has become even more attainable with the help of technology. Lessons have become more interactive with the inclusion of videos and online learning games. This transformation has, in its own way, carved a new path that leads up to a new generation of learning and has eventually witnessed a greater acceptance towards the implementation of technology within the education field. The value of technology will seemingly only increase over the coming years, paving the path for additional developments. The case study research presented here of the integration of technology into an educational organisation is specific to the context in which it was used but has wider implications internationally for the readiness of teachers to access the full potential of technology.

LIMITATIONS AND DIRECTIONS FOR FURTHER RESEARCH.

There are certain limitations to our research.

The drawback is the relatively small sample size of participants who took part in Phase One interviews. There were only 8 participants and out of which 6 of them fell under the age range of 40 years and below. Among the 6 participants, 4 of them belong to the EduTech team. On the other hand, the other 2 participants were above 50 years of age and 1 of them did not belong to the EduTech team. The age group of these participants may also inadvertently impact their beliefs and perceptions toward the use of technology. Overall, considering the participants' age group and integrating their opinions and interactions with technology, this could affect the research's findings, especially given the small sample size and variable levels of tech use dependent on each participant's exposure within the DAS. Hence, this makes it difficult to interpret and extrapolate the data in full.

With this data in hand, a follow-up study will be carried out in the following article to investigate how EdTs within DAS embrace technology and whether the advocacy tier (low, middle, high) they belong to, has an impact on the achievement of the students as measured through our bi-annual curriculum-based assessment.

REFERENCES

Ahmadi, M. R. (2014). The Use of Technology in English Language Learning: A Literature Review. *International Journal of Research in English Education, 3*(2 (6-2018)), 115-125. https://doi.org/10.29252/ijree.3.2.115

Al-Emran, M., Mezhuyev, V., Kamaludin, A. (2018). Technology acceptance model in m-learning con- text: A systematic review. *Computers & Education, 125*, 1–41.

Bolick, C. M., & Cooper, J. M. (2013). Classroom management and technology. In *Handbook of classroom management* (pp. 551-568). Routledge.

Davis, F. D. (1986). A technology acceptance model for empirically testing new end-user information systems: Theory and results [PhD dissertation]. MIT Sloan School of Management.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*, 319–340.

Christopoulos, A., & Sprangers, P. (2021). Integration of educational technology during the Covid-19 pandemic: An analysis of teacher and student receptions. *Cogent Education*, 8:1. https://doi.org/10.1080/2331186X.2021.1964690

Dawson, K., Cavanaugh, C., & Ritzhaupt, A. D. (2008). Florida's EETT Leveraging Laptops, *Initiati 41* (2):143-159. https://doi.org/10.1080/15391523.2008.10782526

Ertmer, P. A. (1999). Addressing first- and secondorder barriers to change: Strategies for technology integration. *Educational Technology Research and Development 47*(4):47-61. https://doi.org/10.1007/BF02299597

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research.* Addison-Wesley.

Gilakjani, A. P. (2014). A Detailed Analysis over Some Important Issues towards Using Computer Technology into the EFL Classrooms. *Universal Journal of Educational Research, 2,* 2 p146-153 2014. https://doi.org/10.13189/ujer.2014.020206

Goodsall, H. (2021). *The Impact of Covid on the Dyslexic Community Report on Findings from BDA Surveys 7th March – 3rd April 2021*. British Dyslexia Association. https://cdn.bdadyslexia.org.uk/uploads/documents/Impact-of-Covid-on-Dyslexic-Community.pdf?v=1632142248

Granić, A., & Marangunić, N. (2019). Technology acceptance model in educational context: A systematic literature review. *British Journal of Educational Technology, 50*(5), 2572–2593.

Liu, I., Chen, M., Sun Y., Wible, D., & Kuo, C. (2010). Extending the TAM model to explore the factors that affect Intention to use an online learning community. Computers *& Education, 54*(2), 600–610.

Milman, N. B. (2020). *This Is Emergency Remote Teaching, Not Just Online Teaching. Education Week.* https://www.edweek.org/leadership/opinion-this-is-emergency-remote-teaching-not-just-online-teaching/2020/03

Mubarak, S., & Ram, G. S. (2016). The Integrative Technology Initiative (ITI) at Dyslexia Association of Singapore (DAS). *Asia Pacific Journal of Developmental Differences, 3*(2), 210-227. https://doi.org/10.3850/S2345734116000272

Mubarak, S. B. (2017). Attitudes Towards New Technology In Teaching Dyslexics In Singapore: The Case Of The Mimio Teach Smart Bars. Asia *Pacific Journal of Developmental Differences, 4*(2), 265-285. https://doi.org/10.3850/S2345734117000149

Padilla-Meléndez A., Del Aguila-Obra A., Garrido-Moreno A. (2013). Perceived playfulness, gender differences and technology acceptance model in a blended learning scenario. *Computers & Education, 63*, 306–317.

Raja, R., & Nagasubramani, P. C. (2018). Impact of modern technology in education *Journal of Applied and Advanced Research. 3*(1), 33. https://doi.org/10.21839/jaar.2018.v3iS1.165

Ritchie , D., & Wiburg, K. (1994). Educational variables influencing technology integration. *Journal of Technology and Teacher Education 2*(2):143-153.

Willis, C. (2020). *The impact of Covid-19 on children's learning. NFER - National Foundation for Educational Research.* https://www.nfer.ac.uk/news-events/nfer-blogs/the-impact-of-covid-19-on-children-s-learning/

Winter, E., Costello, A., O'Brien, M., & Hickey, G. (2021). Teachers' Use of Technology and the Impact of COVID-19. *Irish Educational Studies, 40*(2), 235-246, Taylor & Francis Online. https://doi.org/10.1080/03323315.2021.1916559

APPENDIX

Interview questions for users with high technology usage

QUESTION
In your mind, what is educational technology?
ATTITUDES
What do you think about the use of educational technology in classrooms?
Do you use Edutech in your classroom? Why or why not?
Does technology in the classroom help with your lessons? How so or why not?
When was the first time that you encountered Edutech? Have you used it in your previous experiences?
What was your initial impression about it?
Are you referring to in DAS or elsewhere?
What are some of the Edutech that you first used?
How about currently in DAS?
Are you still using them now? Do you use other Edutech apart from the ones you were first introduced to?
USABILITY
How do you decide which Edutech to use?
How have you incorporated technology into your lessons? Can you provide some examples? What do you use Edutech for? What is the ease of using Edutech? How often do you incorporate the use of Edutech in your lessons? Do you think Edutech is effective for you in your role? Why or why not?
What are some effects of using technology to teach?
Can you elaborate on the benefits and challenges of using Edutech?
OUTCOMES
What are some of the student outcomes that you observe in using Edutech in your classroom?
How does it help them in learning the content? Cognitive (How does it help in understanding?) Engagement (socio-emotional, motivation) Why? Why not? How?

PEDAGOGY
How frequently do you incorporate technology into your lessons? (For e.g., within a week?)
How do you use technology to teach your students? Can you take me through your lesson plan where you incorporate Edutech in your lesson? ~~(Use)~~ Can you tell me why you do not use technology as much? (Use minimally)
Can you describe your teaching approach with regards to the use of technology? Do you allow students to use technology independently/do you control their usage.
Within some of the educational programs that you use, what are some typical functions within those programs you use? Why do you like them? Are there some functions that you are aware of that you don't use? What do you do with it?
What are some teaching materials that you put into these functions?
Based on what you know, do your colleagues at DAS use the same approach and programs as you?
EFFICACY
As an educator, how confident/comfortable are you with using Edutech? To what extent do you feel prepared to select and use Edutech? Do you feel that you are being sufficiently supported/encouraged to use Edutech in class?
ENVIRONMENT
To what extent does your environment/organisation support and/or encourage you to use technology in the classroom? Current efforts by DAS? Colleagues support?
EFFICACY
What are some of the factors that affect your use of Edutech?
Personal (confidence, anxiety, personal preferences) What has helped you gain confidence or held you back? What are some challenges that you have about using Edutech? What do you think can increase your confidence in using Edutech?
Organisational (environmental, work, organisational) factors What are the factors that can be made to support the use of technology in the classroom?

EXPERIENCES
What are the limitations of current technology/technological platforms in DAS? Can you provide an example? (fit into challenges)
What would you change about the current use of Edutech (work process/types/ implementation) in DAS? Why do you say this? Is there anything you would like to improve on?
What sort of technology do you think is useful for DAS?
COVID-19
When you first heard about the full HBL approach, what were your initial impressions about it? Have these concerns changed? Why or why not?
Now in this current COVID situation where it is fully online learning, what are some of the Edutech that you use to teach? Can you show me a typical lesson plan you used recently?
What technologies or platforms are you using to conduct your online classes?
Why are you using it? How are you using Edutech to teach? (the differences & adaptability) What do you like / dislike about it?
Are these different from what you have used before? How easy was it to adapt to the use of them? What are some of the challenges you faced in using these technologies?
What are the student outcomes during the HBL? How likely are you to continue using the tech after the COVID situation?
Has teaching with the use of Edutech during this COVID-19 period changed your perception on Edutech use in the class? How so?
DREAM QUESTION
In 5 years' time, what progress would you like to see in the special needs sector in relation to educational technology
MISCELLANEOUS NOTES

Interview questions for users with low/no technology usage

QUESTION
In your mind, what is educational technology?
ATTITUDES
What do you think about the use of educational technology in classrooms?
Do you use Edutech in your classroom? Why or why not?
Why do you not use Edutech in the classroom?
When was the first time that you encountered Edutech?
What was your initial impression about it?
Are you referring to in DAS or elsewhere?
What are some of the Edutech that you have used?
Are you still using them now? Do you use other Edutech apart from the ones you were first introduced to?
If you don't prefer to use technology, what do you typically use to teach your students? Why this approach instead of technology? What are some effects of using your approach to teach? Can you elaborate on the benefits and challenges of using Edutech?
OUTCOMES
What are some of the student outcomes that you observe in using (their approach) in your classroom?
How does it help them in learning the content? Cognitive (How does it help in understanding?) Engagement (socio-emotional, motivation) Why? Why not? How?
PEDAGOGY
How frequently do you incorporate technology into your lessons? (For e.g. within a week?)
Is there a reason why you don't use it at all? (Don't use)
Can you describe your teaching approach with regards to the use of technology? Do you allow students to use technology independently/do you control their usage?
Within some of the educational programs that you use previously, what are some typical functions within those programs you might have tried and used? Why do you like them? Are there some functions that you are aware of that you don't use? What do you do with it?
Based on what you know, do your colleagues at DAS use the same approach and programs as you?

EFFICACY
Do you feel that you are being sufficiently supported/encouraged to use Edutech in class?
ENVIRONMENT
To what extent does your environment/organisation support and/or encourage you to use technology in the classroom? Current efforts by DAS? Colleagues support?
EFFICACY
What are some of the factors that affect your use of Edutech?
Personal (confidence, anxiety, personal preferences) What has helped you gain confidence or held you back? What are some challenges that you have about using Edutech? What do you think can increase your confidence in using Edutech?
Organisational (environmental, work, organisational) factors What are the factors that can be made to support the use of technology in the classroom?
EXPERIENCES
What are the limitations of current technology/technological platforms in DAS? Can you provide an example? (fit into challenges)
What would you change about the current use of Edutech (work process/types/ implementation) in DAS? Why do you say this? Is there anything you would like to improve on?
What sort of technology do you think is useful for DAS?
COVID-19
When you first heard about the full HBL approach, what were your initial impressions about it? Have these concerns changed? Why or why not?
What was your initial impression, thoughts, concerns on the full HBL approach?
Now in this current COVID situation where it is fully online learning, what are some of the Edutech that you use to teach? Can you show me a typical lesson plan you used recently?
What technologies or platforms are you using to conduct your online classes?
Why are you using it? How are you using edutech to teach? (the differences & adaptability) What do you like / dislike about it?
Are these different from what you have used before? How easy was it to adapt to the use of them? What are some of the challenges you faced in using these technologies?

What are the student outcomes during the HBL? How likely are you to continue using the tech after the COVID situation?
Has teaching with the use of Edutech during this COVID-19 period changed your perception on Edutech use in the class? How so?
DREAM QUESTION
In 5 years' time, what progress would you like to see in the special needs sector in relation to educational technology
MISCELLANEOUS NOTES

Asia Pacific Journal of Developmental Differences
Vol. 10, No. 1, January 2023, pp. 119—136
DOI: 10.3850/S234573412300050X

Identifying Training Needs in Using Educational Technology: a New Integrated Model

Soofrina Binte Mubarak[1*]

1. *Dyslexia Association of Singapore*

ABSTRACT

The coronavirus global epidemic compelled over 190 countries to cancel traditional face-to-face classes and transition to remote learning - suddenly, unexpectedly, and unevenly (UNESCO, 2021). According to UNESCO (2021), at the height of the crisis, more than 85% of students around the world were absent from regular school, and by October 2020, 108 nations reported missing an average of forty-seven days of face-to-face instruction - or approximately a quarter of the academic year. Digital technologies have the potential to revolutionize education worldwide if used properly in the classroom. The COVID-19 pandemic has had some positive effects, such as accelerating the adoption of digital technologies in schools. The extensive use of remote learning opened the door to further digitalization, including the fusing of digital tools with conventional teaching techniques. But bringing traditional pedagogies or approaches online is only one aspect of effective digital learning. The pandemic demonstrated how digital tools were thrown into remote learning carelessly and unevenly. Digital solutions frequently rested on the creativity of a single teacher or the commitment of a single school administrator. Teachers required assistance and instruction on how to use digital technologies effectively if they are to do so. Training for an educational culture that uses digital technologies to improve its operations has become more and more crucial. This paper looks at three prominent training needs analysis models before formulating a new integrated model in the second part. The function of analyzing training needs is one that is acknowledged as being a crucial element of all effective training programmes. In its simplest form, requirements assessment is the act of determining "what is" and "what should be" and proposing solutions to close the gaps between them. This method produces information that can be used to help planning, decision-making, and problem-solving initiatives. This information can be used internationally to investigate educators' current use of technology and desired level of use of technology; and then propose training and non-training solutions to bridge the identified gaps.

Keywords: Educational Technology, training, digital technologies, educational therapists

* *Correspondence to:*
Soofrina Binte Mubarak, Senior Educational Therapist and EduTech Coordinator, Dyslexia Association of Singapore.
Email: Soofrina@das.org.sg

INTRODUCTION

Over the years, the definition of educational technologies has undergone numerous changes as a result of different approaches to dealing with learning processes, conceptual frameworks, theory and practice, as well as the most recent research and ethical standards for integrating technological resources and processes. Although the term "application of educational technology" has many different definitions, this study will use the concept of the activity of designing, developing, utilizing, managing, and evaluating classroom technologies that are linked with learning processes. Projectors, Smart Boards, PCs, tablets, and software for teaching and learning including GSuite (Google Docs, Google Slides), Microsoft Office, and online and app-based tools are a few examples of educational technology that may be found in DAS classrooms.

Educational Technology

In the Dyslexia Association of Singapore (DAS), the phrase "educational technologies" was first used in 2005 in conjunction with touch-typing, although the initiatives were modest in scope and not organization-wide. In order to support therapists' use of educational technology in the Main Literacy Programme classes, further organization-wide measures were launched in 2015, including the acquisition of 334 iPads. Projectors, SMARTboards, and MimioTeach Interactive systems were also introduced in addition to iPads. Numerous web- and application-based tools were also introduced in addition to the hardware. It is now time to assess the expected degree of technology use for remediation and see if the therapists are adhering to those criteria after some years of exploratory uses of educational technologies.

Importance of Educational Technology in Special Education

We are seeing borders gradually disappear in the modern world. This approach has applications outside of business and politics. Nowadays, practically everyone can access medical or educational services anywhere in the world, regardless of citizenship or physical condition.

Due to cognitive, physical, and sensory impairments, students with special education needs have difficulties learning. They stand out due to their variability. Improving these pupils' conduct and interactions with their environment must be one of the key goals of the classroom. However, they also need to learn how to carry out everyday tasks on their own, communicate better, grow intellectually, and discover new things. Learning opportunities should be given to disabled students so they can reach their full potential. They should not face prejudice but should be allowed to engage in education and training on the same terms as pupils without impairments and special educational needs . Educational technologies are now widely used and freely available as a result of the information technology industry's development, which makes it possible to use

them to give students new opportunities which were previously not possible.

The US had 6.7 million children receiving services under the Individuals with Disabilities Education Act (IDEA) in 2015–2016, according to the National Center for Education Statistics. This figure equates to 13% of all students in public schools. While the proportion of these students has been largely constant over the past few years, their overall number has grown by 0.3 million since 2011–2012. The National Center For Education Statistics web page displays the percentage distribution of the various forms of impairments. These students have the chance to participate in fundamental drill and practice, simulations, exploratory, or communication activities that are tailored to their particular needs and talents thanks to technology (Bertini & Kimani, 2003; Edwards, Blackhurst, & Koorland, 1995).

On the home front, Singapore has put a lot of work into creating processes that are more inclusive in the educational system since the early 2000s. In order to improve the quality of support for learners with special needs and/or disabilities in both mainstream and SPED schools, the Ministry of Education (MOE) and Ministry of Social and Family Development (MSF) have collaborated with Voluntary Welfare Organisations (VWOs).

Teachers who use inclusive classroom strategies and allied educators with expertise in learning and behavioral support work with over 27,000 students in mainstream schools who have mild special education needs. 7,000 more children with moderate to severe needs are currently enrolled in 22 Sped schools. This represents around 20% of all pupils who were reported to have special educational needs (Teng, 2022).

The potential advantages of computer-based instruction are founded on fundamental principles of learning theory and apply to all students, including those who have modest disabilities and those who do not. When a computer is used to give well-designed and well-managed instruction through curriculum changes, technology use can improve a student's acquisition of skills and subject-matter knowledge (Woodward & Rieth, 1997).

In Singapore, since 2018, the Infocomm Media Development Authority (IMDA) and Society for Persons with Disabilities (SPD) have jointly set up eight satellite loan-libraries in polytechnics and colleges for assistive and information technology devices. This initiative helps students to try out the various devices and softwares before purchasing the most suitable one. In 2020, to support students with special needs acquire basic digital skills, the MOE introduced the Baseline Digital Skills training, which includes cyber wellness, cyber security, information literacy and using digital technologies on a day-to-day basis. This is part of the National Digital Literacy Programme, which aims to strengthen students' digital literacy and introduce new educational technologies.

Actual Use of Educational Technology in Classrooms

There are many variables that influence how teachers use technology in the classroom. According to national and international data, schools all over the world are getting better and better computer equipment (Collis et al., 1996; Statistics Canada, 1999) and Internet connectivity (Statistics Canada, 1999; Greene, 2000; Riel & Becker, 2000). However, descriptive statistics that show Internet connections and student-to-computer ratios do not provide much information regarding the type and volume of computer-related interactions between students and teachers. For instance, Rosen and Weil (1995) found that although computers were present in almost all of the schools they studied, barely 50% of the teachers actually used them. Similarly, Cuban et al. (2001) discovered that at schools with high access to computer technology, just 4 out of 13 teachers had significantly changed how they taught in the classroom.

From the studies done so far, there may be a wide range of potential obstacles standing in the way of a successful application of computer technology. These obstacles range from equipment-based problems, such as restricted access (Sutton, 1991; Rocheleau, 1995), technical issues and malfunctions (e.g., Hadley & Sheingold, 1993; Sandholtz et al., 1997), to individual differences in attitudes and abilities among teachers (e.g., Becker, 1994; Anderson, 1996; Becker & Ravitz, 2001; van den Berg, 2002; Wood et al., 2002), as well as social issues that impact more widely (e.g. Podmore, 1991; Schofield, 1995). It is difficult to assess the long-term effects of these possible impediments due to the quick development of computer technology and the shifts in educational technology policies. For instance, the access difficulties that were raised in the early 1990s may no longer be pertinent to today's instructors given the greater usage of technology in schools. Significant changes in computer use and technical challenges have been observed in short-term longitudinal studies at intervals as short as two years (Conlon & Simpson, 2003).

Similar to this, as more teachers with computer experience enter the teaching profession and as less experienced computer users have greater access to workshops and training, individual characteristics such as "technophobia" or computer anxiety, which have been identified as a reason why teachers do not implement computers despite increased availability of hardware, may become less of a concern. The degree and prevalence of anxiety may or may not be a concern to teachers given that high computer anxiety is typically associated with low levels of knowledge and experience with computers (e.g. Anderson, 1996; Wood et al., 2002) and that even simple interventions such as giving teachers information and practice using computer technology reduce computer anxiety (Wood et al., 2002).

Given the evolving level of technology integration into the classroom coupled with teachers' confidence levels of handling technology, regularly conducting training needs analysis can be a fruitful approach to assess how well training programs are working.

Organizational leaders might, for instance, go through the process again every six months to assess if they have successfully filled the skills shortages they were targeting.

AIM OF STUDY

The purpose of this study is to provide a new model to identify the obstacles to the use of educational technology in supporting children with special needs internationally. More specifically, to help therapists in the DAS Main Literacy Programme identify any gaps between what they now know and can accomplish and what they should and might know about using and integrating educational technology in their remediation of dyslexic learners.

It has been noted through observation that the ability to consciously incorporate educational technology into the lesson design is allegedly still not prominent in its application, despite having deep knowledge and skill sets to provide remediation for dyslexic learners. If appropriate steps are taken to close the gaps in the therapists' knowledge, competence, and attitudes, this might have an impact on the organization's goals.

Identifying the Source of the Performance Gap

At the time of this study, there was little published literature on technology-based training needs assessments for educators worldwide, and there is a need to identify the reasons for this. This is also true in Asia, working in Singapore's special education sector. There is a need to identify knowledge and skill gaps among DAS therapists in their efforts to integrate educational technologies into the remediation sessions for dyslexic students, given the paucity of publications in this area, and even greater lack of local publications. The growing need and interest in educational technologies, particularly for students with learning differences like dyslexia, motivates this study.

What are Performance Gaps?

A performance gap in training is the discrepancy between what trainees should be doing and what they actually do. These gaps can be located and their causes ascertained with the aid of data analysis, essentially a needs assessment. Training programs that will aid employees in bridging these performance gaps can be created if the causes are correctly identified through a needs assessment.

Training vs Non-Training Needs

Needs assessments are the most crucial sort of analysis for instructional design since they inform whether or not training is required to solve the current problem. This is due to managers' natural tendency to request training right away even when it will not address

the performance issue or yield the expected results.

Needs analyses are carried out to identify the root causes of a company's performance problems. The right remedies can be devised or suggested once the problem(s) have been located and fully understood.

Needs analyses specifically respond to two important questions:

- Why are employees not working at the level they are expected to (desired standard)?
- What will enable them to function to the desired standard?

As one might expect, the answers to the first question directly influence those to the second. If it is discovered that employees are not performing at the level expected of them due to an organizational problem (such as not having access to a tool they require), then it would be appropriate to address the organizational barrier rather than attempting to solve the problem by providing training.

Training is designated for a particular kind of performance issue; it can only assist in resolving the problem when the issue is brought on by a knowledge or skill gap. Therefore, if employees cannot perform at the expected level because they lack the knowledge or skills to do so, training will aid them in moving closer to the performance objective. Needs analyses are therefore carried out before any other studies because of this.

The training requirements analysis is used to examine whether training is the best solution to a workplace issue once a performance gap has been identified. Often, a training requirements analysis reveals the need for training that is specifically targeted (McArdle, 1998, p. 4). An organization can confirm that training is the best course of action for a performance issue by carrying out an effective assessment (gap).

Problems brought on by subpar system design, insufficient funding, or understaffing cannot be resolved by training (Sorenson, 2002, p. 32). Sometimes improving an employee's knowledge and abilities would not fix the issue or shortcoming, therefore training would be a waste of time and money.

The needs analysis ultimately establishes the need for training, specifies the sort of training required, and looks at the kind and extent of resources required to support a training program (Sorenson, 2002, P. 32). Training Needs Analysis (TNA) can be used to identify the knowledge and skills necessary to fulfill organizational goals (Brinkerhoff & Gill, 1994), while it can also be used to determine the nature and scope of performance issues and how to address them (Molenda, Pershing & Reigeluth, 1996).

The performance analysis model developed by Mager and Pipe (1997), the synthesized human performance technology developed by David Wile, and the purpose-based model developed by Rossett are some of the primary models for needs assessments that will be covered in the part that follows.

Training Needs Analysis Models

Three well-known needs analysis models that are regarded appropriate for the training needs analysis at the DAS are described and discussed in this section.

Performance Analysis Model

The Performance Analysis Model, developed by Mager and Pipe (1997), is a method for analyzing performance issues. It is organized as a thorough flow chart (Table 1) with questions and instructions based on possible replies that are directed by seven steps, as shown in Table 1 below.

Table 1. The Seven Steps of Performance Analysis Model, (Mager & Pipe, 1997).

Step 1	What is the performance problem?	Description of performance deficiency: *What should be happening?* *What is actually happening?*
Step 2	Is it worth fixing?	What would happen if nothing was done to fix it?
Step 3	Can a quick fix be applied to the performance problem?	Do the employees know what is expected of them? Are the employees equipped with adequate tools / equipment / resources needed? Do employees receive feedback on their performance?
Step 4	Are the consequences appropriate?	Is the desired performance punishing? Is poor performance rewarding? Are performance consequences used effectively?
Step 5	Is there a skill deficiency?	Is it a skill deficiency? Could employees do it previously? Is the skill used often?
Step 6	Are there other causes?	Can task be made easier? Are there any other obstacles? Do the employees have the potential to change?
Step 7	Which solutions are the best?	Are the solutions feasible? What are the costs of possible solutions? Draft and implement the action plan.

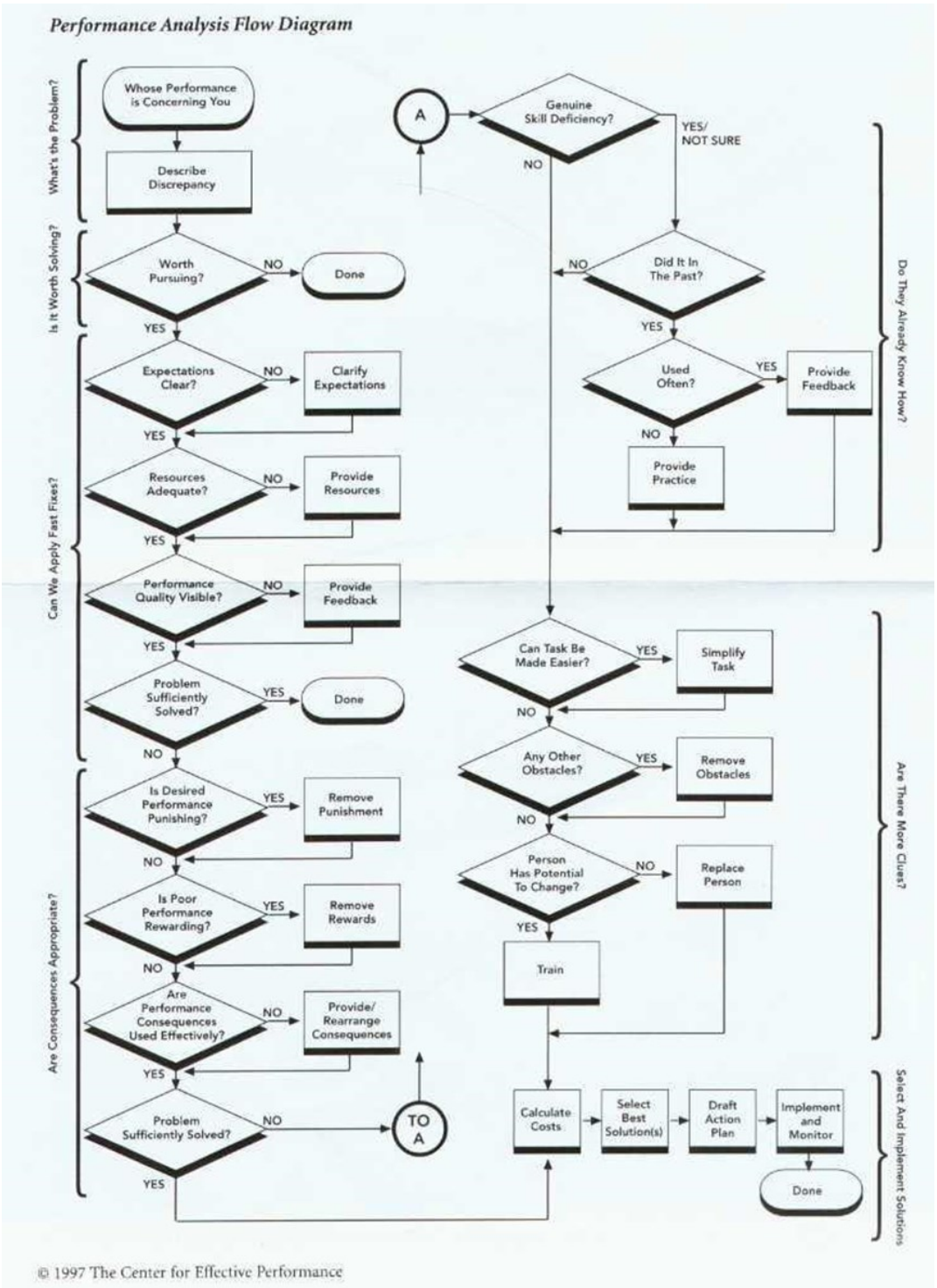


Figure 1: Performance Analysis Model Flowchart. Source (Mager & Pipe, 1997, p. 32)

With reference to figure 1, the framework of this model is created to be applicable to actual interactions between instructional designers and customers. Although in theory Mager and Pipe's (1997) model claims that non-training solutions could eliminate performance issues like unclear expectations, unclear performance measures, insufficient resources, and rewards/consequences not directly linked to the desired performance outcome, it may be misleading to inexperienced practitioners who may not fully understand how other performance factors function in relation to training. Mager and Pipe's model provides a one-to-one ratio of training to performance factors. For instance, Gilmore's (2009) research on illustrative cases in human performance technology (HPT) reveals that organizational systems are often the main factors affecting performance, with incentives coming in at a close second, followed by training in third place.

The reach of Mager and Pipe's paradigm includes each performer directly and, indirectly, the entire organization. Furthermore, the approach is basically reactive and is primarily designed to modify the status quo at the level of performance for individuals and small groups.

The model has the benefit of directing a methodical examination to find performance-related solutions. It places a strong emphasis on cost effectiveness when resolving performance issues at every stage, including deciding whether the issue is even worth fixing, selecting less expensive non-training solutions over training solutions, and identifying simpler solutions; however, it does not specifically describe the method by which alternative solutions are generated. Additionally, despite this being a goal of the "Performance Analysis Flow Diagram," Mager and Pipe do not specifically address formative review and continual improvement based on data-driven decision making.

In terms of choosing an intervention, the Mager and Pipe (1984) methodology uses a flowchart approach to connect particular treatments to the results of performance analysis. As a result, it helps to eliminate a gap between real and desired performance. However, the model does not offer much advice on how to choose the "best solution(s)". The cost-effectiveness, practicability, and feasibility of the treatments are the sole criteria offered for evaluating them by Mager and Pipe (1984).

Synthesized Human Performance Technology

Wile researched five widely used models of human performance and sought to reconcile the differences between them in order to provide a synthesis of the various factors that have been recognized as influencing performance. By conceiving his Synthesized Human Performance Technology (HPT) Model, Wile (Wilmoth, Prigmore, & Bray, 2014) offers insight into the factors that influence human performance. Wile distinguishes between internal and external factors in connection to the performance in this model (figure 2), and then further separates the external domain into intangible and tangible categories, emphasizing that each requires a particular set of interventions.

The following performance criteria are listed by Wile:

a) Organizational system
b) Incentives
c) Cognitive support
d) Tools
e) Physical environment
f) Skill and knowledge
g) Inherent ability

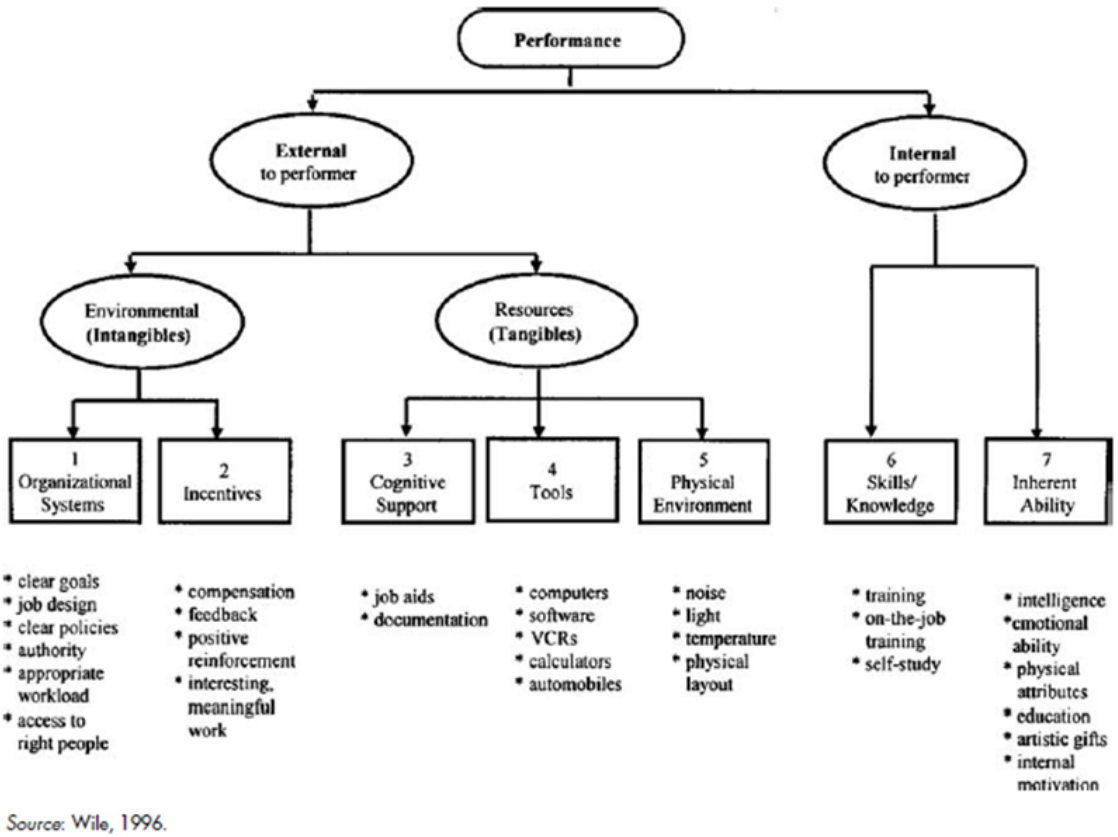


Figure:2 Wile's Synthesized HPT Model. (Source: Wile, 1996, 35(2), 30-35)

This approach is distinctive in that it distinguishes between interventions that are training-based solutions and those that are not and provides actual solutions to a variety of performance issues. The user can quickly start correcting a performance issue because of the straightforward diagnostic procedure in this model.

In the context of performance enhancement, it is crucial to take into account whether the variable is internal to the performer or external to the performer. Wile focuses in, and

distinguishes between tangible and intangible factors that are external to the performing entity. Organizational structures and incentives are examples of intangibles. Tangibles are components of the physical environment, tools, and cognitive assistance. Wile (1996) does not, however, explain the selection process or connections between the cited performance factors. Quantifying the amount of each performance aspect required to improve performance would therefore be challenging for the model's user.

This model explains why using technology to fix performance issues is not a simple fix. For instance, even if a technology tool is available, performance might not increase if the true problem is that a person lacks the motivation to finish an academic job. Likewise, speed improvements will be constrained if a tool is only accessible in one environment.

Purpose Based Model

The goal of Allison Rossett's model is to close the performance gap between "ideal" and "actual" performance for individuals and small groups. It is perhaps one of the most popular training requirements analysis methods now utilized by business and industry. Rossett's definition of TNA is "The study to design and develop instructional and informational programs and materials, after the performance analysis has determined that training and informational materials are indeed appropriate."

An initial examination of the situation is conducted prior to doing a needs assessment in order to evaluate whether a more thorough TNA is required. In order to complete this activity, one must first determine the cause of performance gaps (causal analysis), after which one must acquire opinions and ideas utilizing mostly qualitative data collection techniques like surveys and interviews. Performance issues, new systems and technologies, and automatic or habitual training are the three categories of initiators listed by Rossett as causing the requirement for TNA processes (Rossett, 1987).

She suggests that the framework for assessing the needs for purpose-based training would be helpful in determining what potential causes might underlie the initial issues and what pertinent data might be acquired to determine the remedies. This is because the Purpose-Based Model's method for conducting TNA is extremely targeted and it aids in the planning of what data should be gathered.

One is interested in the knowledge, abilities, and attitudes that employees need to have in order to perform the job as expected (Rossett, 1987) when looking for information about optimals. The actuals would represent what the personnel already know and are capable of doing at this time. The discrepancy between these data (optimals and actuals) reveals performance gaps or areas that require improvement. The employee's views or ideas about their duties or new responsibilities must be taken into account, however, since they may shed light on why some processes or activities do not go as planned. Performance gaps must have causes or reasons, and it is desirable that

recommendations and solutions to close the gaps are offered after extensive, thorough fieldwork.

Four different categories of information are obtained during TNA using Rossett's purpose-based model:

- Optimal performance requirements - What are the staff members' expected levels of performance?
- Description of current performance – What are staff doing right now, and how are they doing it?
- What are the key players' feelings on the problem or the new adjustments at the grassroots level?
- What are the possible solutions to the issue, and how might they be prioritized?

Rossett (1987) suggests using the suitable TNA techniques and instruments to carry out the investigations in an effort to get the answers to these aims. The decision can be made based on:

a) how the TNA objectives affect the procedures and questions that are chosen, and
b) how the context affects the methods used and the information sources contacted.

Table 2. Causes and solutions of performance problems (Rossett, 1997)

Causes	**Lack of skills or knowledge**	**Shortcomings of incentives**	**Shortcomings of environment**	**Lack of motivation**
Information Needed	Are the learners able to do the task?	Feeling, consequences of task performance	Environmental support	Feelings
Possible Data Sources	Records and outcomes, observation, interviews	Observation, Interviews, focused groups, records, questionnaire	Observation, interviews, focused groups	Interviews, questionnaires
Solutions	Job-aids Training Coaching Mentoring	Enhanced policies Training for supervisors Improved incentives	Redesign of work environment / layout Enhancement of tools Proper matching of task and employee	Training to improve success (confidence) Reward system to boost morale Recognition of effort Coaching

The TNA approaches include tools including questionnaires, surveys, focus group discussions, observations, and interviews as well as analysis techniques include existent data analysis, needs assessment, subject-matter analysis, and task analysis.

Rossett (1997) also provides the following possible causes of performance problems and their possible solutions (See Table 2).

Introducing the Integrated Model

Given the benefits and drawbacks of each model discussed in the preceding sections, an integrated strategy has been developed (figure 3) to holistically draw on the breadth and depth of Wile's Synthesized Human Performance Technology Model, Rossett's Training Needs Assessment Approach, and Mager and Pipe's Performance Analysis Model.

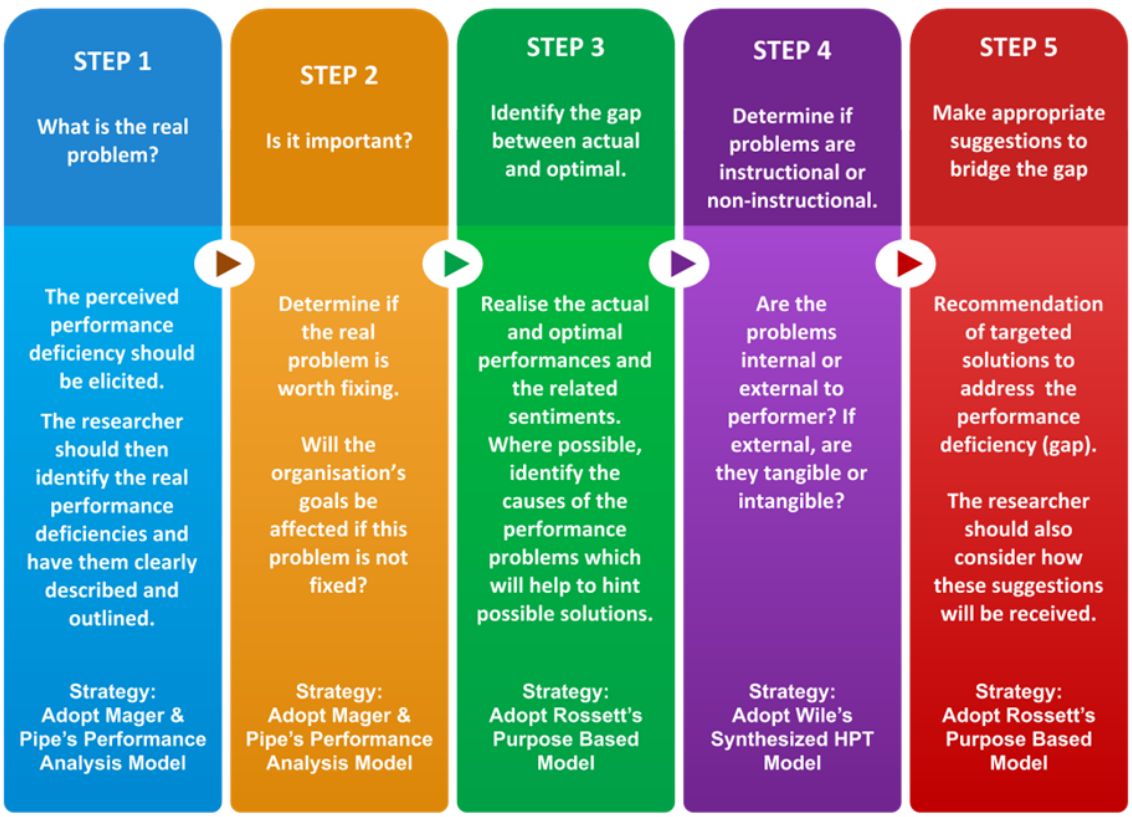


Figure 3: Integrated TNA Approach used in this study

Overall, the Integrated Approach consists of the following five major steps:

Step 1	**What is the real problem?**	a) probing of the perceived performance deficiency b) identification of the real performance deficiency
Step 2	**Is it important?**	c) determining the importance of the performance deficiency d) determining the impact on the organisation's goals if the performance deficiency is not addressed
Step 3	**The gap between the actual and the optimal**	e) identifying the gap between the actual and the optimal performance levels f) understand the sentiments on the ground with regards to the current and optimal performance levels g) investigating the possible causes of the gap
Step 4	**Is training the solution?**	h) determining if the problems require training or non-training solutions
Step 5	**What are the possible solutions?**	i) recommending possible solutions with considerations to acceptance and feasibility

It is simple to assume that giving everyone the same set of knowledge and abilities will fix performance issues from your point of view. However, it might not always be a training issue, or even a problem that has to be fixed. For stages 1 and 2, the Integrated TNA Approach uses the Performance Analysis Model developed by Mager and Pipe. The Performance Analysis Model guides the user through the initial steps of problem identification and helps them decide whether or not the issue warrants fixing.

The third step entails identifying the current standards (actual) and establishing the ideal standards (optimal) by gathering data from various stakeholders and subject matter experts using a variety of tools such as focus groups, focus interviews, surveys, and observation. As it is thorough and covers four types of information in the data collection process, Rossett's Purpose Based Model will be used for this step. These are a) specifics of optimal/desired performance, b) description of current/actual performance, c) emotions on the ground levels, and d) causes to the problems which can lead to targeted solutions. The Purpose-Based Model aids in locating potential causes of performance issues, such as a lack of abilities, inadequate rewards, an unfavorable environment, and a lack of drive. These are obtained by comprehending the levels of ideal performance, analyzing actual performance, and determining the discrepancy between these two standards.

The next stage will be to identify if the problems are instructional or non-instructional in nature, which would indicate whether or not the solutions are training-related. Wile's Synthesized HPT Model is used to examine performance as a whole, including the performers' cognitive and action tasks. First, Wile's Synthesized HPT Model aids in separating the EdTs—external and internal factors influencing the performer—from each other. Skills, knowledge, and ability would constitute the EdTs' internal factors. The model divides the external variables into tangible and immaterial components. Organizational structures and incentives are examples of intangible elements, whereas tools, the physical environment, and cognitive support are examples of tangible factors. The proper selection of solutions for each problem in the subsequent stage depends on this classification.

Making recommendations of solutions based on what has been learned about the factors that have led to the performance issues would be the final step. Rossett's purpose -based model is used once more in this situation because it offers insight into a number of perspectives on the underlying causes of the identified performance gaps, including 1) a lack of knowledge and skills, 2) a deficiency in incentives, 3) a deficiency in the environment, and 4) a deficiency in motivation. The adoption of these recommendations will also be taken into account.

DISCUSSION

Human performance has a direct influence on organizational performance. Human performance issues occur when there are reasonable grounds to believe that task performers have the necessary level of capability and knowledge to do what is expected of them, when they may not. Given the strengths and limitations of each model described in the previous sections, the three models will be combined into a five-step integrated model to investigate the training needs for educational therapists in the Dyslexia Association of Singapore by comprehensively tapping on the extensiveness and depth of a process model: Mager and Pipe's Performance Analysis Model; a diagnostic model: Wile's Synthesized Human Performance Technology Model; and a holistic model: Rossett's Training Needs Assessment Approach.

The performance analysis model developed by Mager and Pipe has been identified as a process model. Mager and Pipe's performance analysis model compares the desired performance state (optimal) to the actual performance state (actual) (Burner, 2010; Rummler, 2006). If there are differences between these two states, it is critical to select and implement the appropriate interventions to close the gap between the desired and actual states of performance.

Wile's human performance technology analyzes organizational systems and work environments to optimize effectiveness by determining the underlying causes of performance gaps. While performance analysis can help identify performance gaps

within an organization, human performance technology can help identify the causes of those gaps, addressing the big question of what motivates performance levels.

Rossett's model is based on a systematic study of problems that incorporates data and opinions from a variety of sources. Rossett's holistic approach, as described in section 2.2.3, collects four types of information when planning a needs assessment: 1) Desired performance description, 2) current performance descriptions, 3) ground-level emotions, and 4) ways to solve problems.

DIRECTIONS FOR FURTHER RESEARCH

In Mubarak (2022 in preparation) a complete analysis of the use of the new integrated training needs analysis model with educational therapists will be presented. In order for DAS to plan and get ready for training routes based on the determined training needs of the therapists, the findings from this research and the suggested solutions will be communicated with the organisation.

CONCLUSION

More attention must be paid to the effectiveness of educational technology integration in educational establishments worldwide in order to achieve the optimal impact of educational technologies, particularly with students who have learning differences. The deliberate and meaningful integration of educational technologies will not occur simply because gadgets and resources are available; rather, the main emphasis here is how technology tools enhance the learning experience. This includes insights into why educators integrate educational technologies, how such integration can be effective, and how educators can be better supported to adopt and incorporate technology for teaching in their lessons. This is what the new integrated model, which will be described and used in Part 2 aims to achieve, while remaining straightforward and simple to use.

REFERENCES

Anderson, A. A. (1996). Predictors of computer anxiety and performance in information systems, *Computers in Human Behavior, 12*, pp. 61–77.

Becker, H. J. (1994). How exemplary computer-using teachers differ from other teachers: implications for realizing the potential of computers in schools, *Journal of Research on Computing in Education, 31,* pp. 356–385.

Becker, H. J. & Ravitz, J. L. (2001). *Computer use by teachers: are Cuban's predictions correct?,* paper presented at the Annual Meeting of the American Educational Research Association, Seattle, WA, March.

Bertini, E., & Kimani, S. (2003). Mobile devices: Opportunities for users with special needs. In L. Chittaro (Ed.), *Mobile HCI: Vol. 2795. LNCS* (pp. 486-491). Retrieved from http://abstract.cs.washington.edu/~shwetak/classes/cse599u/notes/Bertini2003.pdf

Brinkerhoff, R. O., & Gill, S. J. (1994). *The learning alliance: Systems thinking in human resource development.* San Francisco: Jossey-Bass.

Collis, B. A., Knezek, G. A., Lai, K., Miyashita, K. T., Pelgrum, W. J., Plomp, T. & Sakamoto, T. (1996). *Children and Computers in School* (Mahwah, NJ, Lawrence Erlbaum Associates).

Conlon, T. & Simpson, M. (2003). Silicon Valley versus Silicon Glen: the impact of computers upon teaching and learning: a comparative study, *British Journal of Educational Technology, 34*, pp. 137–150.

Cuban, L., Kirkpatrick, H. & Peck, C. (2001). High access and low use of technologies in high school classrooms: explaining an apparent paradox, *American Educational Research Journal, 38*, pp. 813–834.

Edwards, B. J., Blackhurst, A. E., & Koorland, M. A. (1995). Computer-assisted constant time delay prompting to teach abbreviation spelling to adolescents with mild learning disabilities. *Journal of Special Education Technology, 12*(4), 301-311.

Greene, B. (2000). *Teachers´ tools for the 21st century: a report on teachers´ use of technology*. US Department of Education, Office of Educational Research and Development.

Hadley, M. & Sheingold, K. (1993). How exemplary computer-using teachers differ from other teachers: implications for realizing the potential of computers in school, *Journal of Research on Computing in Education, 26*, pp. 291–321.

Mager, R. F., & Pipe, P. (1997). *Analyzing Performance Problems: Or, You Really Oughta Wanna* (3 ed.): Center for Effective Performance.

McArdle, G. (1998). *Conducting a needs analysis*. Menlo Park, CA: Crisp Learning.

Podmore, V. N. (1991). 4-year-olds, 6-year-olds, and microcomputers: a study of perceptions and social behaviours, *Journal of Applied Developmental Psychology, 12*, pp. 87–101.

Molenda, M., Pershing, J., & Reigeluth, C. (1996). Designing instructional systems. In R. Craig (Ed.), *The ASTD training and development handbook* (4 ed.). New York, NY: McGraw-Hill.

Riel, M. & Becker, H. (2000). *The beliefs, practices, and computer use of teachers, paper presented at the American Educational Research Association*, New Orleans, LA, April.

Rocheleau, B. (1995). Computer use by school-age children. Trends, patterns, and predictors, *Journal of Educational Computing Research, 12*, pp. 1–17.

Rosen, L. D. & Weil, M. M. (1995). Computer availability, computer experience and technophobia among public school teachers, *Computers in Human Behavior, 11*, pp. 9–31.

Sandholtz, J. H., Ringstaff, C. & Dwyer, D. C. (1997). *Teaching with Technology. Creating Student-centred Classrooms* (New York, Teachers College Press).

Schofield, J. W. (1995). *Computers and Classroom Culture.* Cambridge, Cambridge University Press.

Sorensen, J. B. (2002). The Strength of Corporate Culture and the Reliability of Firm Performance. *Administrative Science Quarterly, 47*, 70-91. http://dx.doi.org/10.2307/3094891

Statistics Canada (1999). Characteristics and features of education systems, in: *Education Indicators in Canada. Report of the Pan-Canadian Education Indicators Program*, Chapter 3, pp. 25–74. Ottawa, Statistics Canada.

Sutton, R. E. (1991). Equity and computers in the schools: a decade of research, *Review of Educational Research, 61*, pp. 475–503.

Teng, A. (2022) *Support available in schools for families caring for special needs children: Chan Chun Sing*, The Straits Times. The Straits Times . Available at: https://www.straitstimes.com/singapore/politics/support-available-in-schools-for-families-caring-for-special-needs-children-chan-chun-sing (Accessed: November 26, 2022).

UNESCO (2021). When schools shut: gendered impacts of COVID-19 school closures. *United*

Nations Educational, Scientific and Cultural Organization, 7, place de Fontenoy, 75352 Paris 07 SP, France. https://unesdoc.unesco.org/ark:/48223/pf0000379270 (Original work published 2021).

Van Den Berg, R. (2002). Teachers' meanings regarding educational practice. *Review of Educational Research, 72*, pp. 577–625.

Wile, D. (1996). Why doers do. *Performance and Instruction, 35*(2), 30-35.

Wood, E., Willoughby, T., Specht, J., Stern-Cavalcante, W. & Child, C. (2002). Developing a computer workshop to facilitate computer skills and minimize anxiety for early childhood teachers, *Journal of Educational Psychology, 94*, pp. 164–170.

Wood, E. , Mueller, J. , Willoughby, T., Specht, J. & Deyoung, T. (2005). Teachers' Perceptions: barriers and supports to using technology in the classroom, *Education, Communication & Information, 5*:2, 183-206, DOI: 10.1080/14636310500186214

Woodward, J., & Rieth, H. (1997). A historical review of technology research in special education. *Review of Educational Research, 67*(4), 503–536. https://doi.org/10.2307/1170519

Asia Pacific Journal of Developmental Differences
Vol. 10, No. 1, January 2023, pp. 137—160
DOI:10.3850/S2345734123000628

The impact of bilingualism on dyslexia: a comparative study of Welsh and English University students using Wordchains.

Margaret Meehan[1] and Angela J. Fawcett[2*]

1. *Swansea University, UK*

Abstract

In this article, 2 studies are presented comparing English and bilingual Welsh speaking university students', including those who experience dyslexia on their speed and accuracy of segmenting Wordchains. In the pilot study, a Welsh translation of the standardised assessment, Wordchains, was evaluated with a group of students. The results indicated that this version was more difficult than the English version because of the longer length of the Welsh words. For the main study, the stimulus was adjusted for length and a comparison made of the performance on Welsh and English forms. The results indicated that the Welsh test was more difficult overall with the poorest performance from Welsh speaking dyslexics followed by Welsh speaking controls than the English test equivalent. The results have implications for countries across the world where bilingualism is common.

Keywords: Bilingualism, processing speed, dyslexia, Welsh, Higher Education

* *Correspondence to:*
Angela Fawcett, Emeritus Professor, Swansea University and Research Advisor, Dyslexia Association of Singapore.
Email: angela@das.org.sg

INTRODUCTION

Bilingualism is extremely common world-wide, with 55 countries identified as bilingual, and 67 countries using English as one of their official languages [Wikipedia, 2022f], which makes this an important issue for research, with impact for many participants internationally. Bilingualism is known as 'simultaneous' when children are learning the language at home as well as in the educational context, and consequential or sequential when only adopted in education or work. English itself can be a major challenge for many people from a variety of backgrounds because of the irregularity and complexity of the English language. In the UK, issues related to bilingualism are becoming ever more relevant with growing numbers of bilingual and EAL (English as an Additional Language) children in school (Strand et al., 2015) with children potentially at a disadvantage in the UK system. In their review of 29 controlled interventions, vocabulary was shown to be key to success for these children, as well as improving listening comprehension, with growing numbers of children with poor language backgrounds of all types increasingly at risk for failure. This may well be a key issue for a number of Asian countries, such as Singapore, where although the language of instruction is English, native languages include Chinese (Mandarin), Malay and Tamil.

The question therefore arises, what is the impact of bilingualism in dyslexia? In this article, this issue will be explored further with 2 studies undertaken and presented here: firstly, a pilot study to evaluate a Welsh version of the Wordchains test (Miller-Guron, 1999) compiled by experts in the field. Secondly, a more comprehensive study using modified Welsh Wordchains stimuli, adapted to match the English stimuli for word length, in comparison between Welsh and English speakers, including participants who experience dyslexia and those who do not.

Costs and Benefits of Bilingualism

For many years there has been controversy over the impact of bilingualism on literacy, because it seems that initially children who are learning to speak in more than one language are delayed. It has even been suggested that this can lead to failure, but conversely research from Kuhl (2004) has argued that children who are learning in more than one alphabetic language will retain their ability to benefit from a wider variety of inputs over a longer period of time than monolingual speakers. The impact of this means that this initial delay (Garcia- Sierra et al., 2011) endows these children with a naturally enriched system of neural networks. This in turn will endow them with greater advantages in executive function, including memory and attention which have themselves been shown to be key to early learning. The impact of this enriched environment is known to increase metalinguistic awareness and competence, which underpin language learning. More theoretically, for example, learning a novel second language such as Hebrew or Chinese will lead to increases in statistical learning, which underpin the framework for learning to read (Frost et al., 2013). Interestingly, there have been suggestions (Lallier

and Carreiras, 2018) that theoretically early bilingualism modulates reading development, with the specific impact linked to the grain size hypothesis triggered by different orthographic depth (Zeigler and Goswami, 2005). This suggests that greater complexity of the language leads to greater difficulty in acquisition, with some languages appearing more compatible than others in terms of both accuracy and fluency, and English the most complex of them all.

Dyslexia and Bilingualism

In order to understand dyslexia in the context of bilingualism, it is necessary to understand how this might impact on literacy and how dyslexia can impact on language learning (Cline, 2000). For example, the orthographic complexity of a language determines how quickly it can be learned (Caravolas, 2005; Ziegler & Goswami, 2005). In a recent report, (Mortimore et al., 2012), a number of issues were highlighted, including the possible masking of dyslexia by difficulties in acquiring a 2nd language in their study of 125 schools with higher than average bilingualism. Strand et al, (2015) identified special educational needs as a major factor in escalating risk levels for bilingual children, but in their study, there was no attempt to differentiate dyslexia from other learning difficulties. A notable exception to this trend, the study by Kelly (2002) found 95% of a group of 200 Bengali children showed automaticity deficits in balance that have been linked to dyslexia, and moreover, that these linked to impaired phonology, in a longitudinal study of 7-8 year-old Punjabi children.

Dyslexia in Higher Education

Academic learning is inevitably considered to be synonymous with reading and writing (Mateos et al., 2007). In reading text, comprehension is related to not only word decoding accuracy (which itself is related to spelling accuracy), but also to phonemic awareness and fluency, (Jackson, 2005) which has implications for dyslexic students in HE (Higher Education), who may continue to struggle in these areas. This is because they will require more time reading for their research before starting a written assignment, and more time at the writing stage than their non-dyslexic peers. It is important to note that the difficulties adults with dyslexia experience can only increase when they are "in situations that place great emphasis on written language skills" (Gauntlett, 1990). University is one such an environment and as stress exacerbates dyslexic difficulties, this may "result in a student with mild dyslexia exhibiting the symptoms of severe dyslexia." (Pavey et al., 2010). Gilroy (2004)has noted the extreme impact of ongoing stress on university students with dyslexia.

Students on degree courses are mainly assessed through written work, but planning and structuring a written assignment can be difficult because students with dyslexia find it hard to put their thoughts into logical, sequential sentences and they can take 10 or 20 times longer than their peers to produce a piece of coursework which may still not be a

true reflection of their ability, (Smith-Spark et al., 2004). Dyslexic individuals may have difficulties with any or all of the following: poor spelling, symbol confusion, omission of words, and difficulty in proofreading. These make for obvious difficulty in academic writing, especially as critical thinking, use of language, structuring and argument are core skills for academic writing, (Elander et al., 2006).

It may be that dyslexic students tend to select courses that demand less writing, for example creative art/design or practical-based mathematics courses such as engineering, biological or physical sciences. Often students with dyslexia excel in presentations where they can talk about their knowledge but they may have difficulty reading their own slides, mispronounce words and make spoonerisms which can result in being an object of fun (Cogan, 2000). Dyslexic students are more likely to be awarded a lower-class degree (lower second or third) and are more likely to withdraw after their first year of study (Richardson and Wydell, 2003 in Mortimore and Crozier, 2006).

In addition, some students with dyslexia may experience visual distortions when reading, such as the letters and words appearing to move on the page; text can form dark patterns on a white background for example, similar to rivulets down the page, or there may just be too much 'glare' from the white page, (Wilkins, 2003). A student with severe visual distortion who reads for more than twenty minutes usually develops itchy and sore eyes, and severe headaches or migraines. Although the cause of this condition has not yet been established, it can be helped by the use of a coloured overlay or coloured lenses, (Evans, 2001).

Not surprisingly, the situation when assessing the literacy skills of adults with dyslexia is even more complex, given the natural overlay of compensatory skills in those students who have managed to progress through to university. Cavalli et al, (2016), for example have shown that University students who experience dyslexia show vocabulary skills equivalent to chronological age controls, and these skills play a major role in comprehension at this level, and these findings are supported by many other studies in the literature. It seems that the defining feature for many adult dyslexics, particularly those who reach university, is the speed factor which means that their performance in reading simple one syllable words, whether regular, irregular or nonwords, may be nearly 3 times slower than their non-dyslexic peers (Nicolson et al., 2010). An important tool that can be used in these contexts would be the Wordchain group reading test (Miller Guron, 1999) which measures the speed and accuracy of segmentation of three and four syllable words. Interestingly, it is clear that the task itself captures the well-researched difficulties that dyslexics suffer in segmenting language efficiently. This test has been designed to evaluate silent reading speed in ages 7 to 18 and therefore is one of the few tests that is suitable for the adult age range in FE (Further Education) and HE. Originally normed for Swedish readers, a series of studies have translated the Wordchains stimuli, to compare reading speed in different orthographies, including English and Swedish, where comparisons were made with primary school children (Miller

Guron and Lundberg, 2004), as well as dyslexic children reading in English as a foreign language in Swedish schools (Miller, Guron and Lundberg, 2000). It has been successfully used in evaluating the cognitive linguistic profiles of multilingual dyslexic University students suspected of dyslexia (Lindgren and Laine, 2010) reading in both Swedish and Finnish, based on normative data and translation (Lindgren and Laine, 2007). More recently, Wordchains was adapted into Arabic and used to evaluate the incidence of dyslexia among young offenders in Kuwait (Elbeheri, Everatt and Al Malki, 2008).

Aspects of the Welsh Language

Welsh is a more orthographically transparent language than English and this affects the rate of acquisition of a language. A transparent language has a regular grapheme (letter) to phoneme (sound) correspondence and rules of pronunciation. It has been suggested that in language acquisition different strategies are used depending on the orthographic depth of the language. A study by Ellis and Hooper (2001) of year 2 children showed the Welsh speaking children were able to read more accurately and fluently than English speaking children, because of the greater orthographic transparency of Welsh, and this meant that the Welsh speakers showed higher comprehension levels. Moreover, the majority of their errors related to word length in Welsh. Mayer et al., (2007) working with Welsh-English bilingual children found that in reading and writing phonological processing seemed to be used preferentially, that is, a reliance on recognising the sounds of syllables and words. Their research found that Welsh children rely on phonological processing when spelling whereas orthographic strategies are more useful when spelling in English where there is a more "complex relationship between graphemes and phonemes".

Welsh may have transparent spelling but it does not have a transparent grammar. Grammatical gender is more complex in Welsh and Welsh speaking children generally do not achieve this skill until they are 10 years old, (Gathercole and Thomas, 2005). Welsh has a system of mutations of initial letters which can make it difficult to look words up in dictionaries, for example Cymru = Wales but Welcome to Wales = Croeso i Gymru. There is also a difference between written and spoken vowel mutation in Welsh (Cartmill, 1976). Possessive Pronouns cause mutations, for example, Cath = Cat

Table 1. Welsh grammar

fy nghath = my cat	ein cath = our cat
dy gath = your cat (informal)	eich cath =your cat
ei chatth = her cat ei gath = his cat	eu cath = their cat

As Welsh has a transparent orthography, children learning to read through the medium of Welsh are more successful at phoneme tasks than children from the same area of

Wales learning to read through the medium of English (McDougall and de Mornay Davies, 2010). Spencer and Hanley, 2003, found that 5 to 6 year-old children were more skilled in real and nonsense words and phonemic awareness, when reading in Welsh than English, although by age 10 this advantage had diminished. A study from Mayer et al., (2007) indicated a differential involvement of phonology in spelling, elicited by a concurrent vocalisation task, which impacted more severely on Welsh spelling, but only impacted on comprehension for the younger Welsh readers in the age group 7-8. Evidence has also been found to indicate that different grain sizes are applied during sentence reading dependent on the languages involved, with bilingual Welsh university students employing different strategies when reading in words embedded in sentences in Welsh or English, including more fixations in Welsh which represent the more consistent orthography (Egan et al., 2019) in response to words rather than pseudo-words. By contrast, the same subjects showed equivalent eye movements to monolinguals when reading English sentences.

Welsh Language and Dyslexia

The implication for Welsh children with dyslexia is that Welsh will be easier to learn than English initially but their difficulties will be more readily seen in English than in Welsh so detection in Welsh may be masked and consequently no support put in place. If children are not identified until much later in their education, for example, at university they can develop low self-esteem and less readily achieve their potential. However, until recently, there has been a shortage of screening tests and standardised instruments for measuring achievement for Welsh speaking dyslexics. Moreover, there has been a profound shortage of studies targeting Welsh speaking dyslexics, and the only study from Thomas and Lloyd, (2008), found that this group had greater difficulty than their peers in reading spelling and copying tasks.

Interestingly, a pattern showing the impact of home language was identified in children from English speaking homes in norm collection for a standardised Welsh screening test (WDT-J, Jones and Fawcett, 2013) 400 children, with 267 from English speaking homes, 180 from Welsh speaking homes, and 34 mixed were screened for risk of dyslexia, between ages 7 and 11. The results in table 2 below indicate that 29% risk level was found overall, with 14.4% risk in Welsh speakers, and 3% of this strong risk (Fawcett, 2000).

Table 2. Incidence of risk in Welsh and English speaking children

Home Language	Mild Risk	Strong Risk
English	34	65
Mixed	5	6
Welsh/English		
Welsh	17	9

One of the most striking aspects here was the impact of Welsh word length on completion time in the Rapid naming task, which meant that naming speed was significantly longer at the lowest level, although speed of single word reading was faster.

Welsh Students Who Experience Dyslexia

A key factor for Welsh students with dyslexia may be that they remain slower reading English than Welsh, because many of them need to translate words from Welsh into English in order to understand the text. In order to help students to read more efficiently strategies such as planning when they are more alert during the day, reading in short bursts, skimming for an overview, deciding on keywords and scanning for them, and using a ladder read can be helpful. If students usually think in Welsh, composition in English may be slower because they are having to translate. This has implications for written assignments and examinations and students may get left behind if copying from a board or taking notes in lectures or seminars particularly as there may be a problem with spelling.

When first language Welsh speaking students are writing in English there can be an over reliance on phonetic spelling and an over use of the definite article and as Welsh syntax is different from English a literal translation from the Welsh might be confusing. A Welsh dyslexic student may need more specific help in developing proofreading skills (Meehan, 2011). Supporting students in Higher Education requires adapting or creating new strategies tailored to the individual student but in terms of proofreading may include noting down the main difficulties the student experiences in English and finding a 'key' to help the student find the correct word and/or spelling. Assistive technology can be used and modified to the individual student. Indeed, the recent increased use of Virtual Learning at all educational levels due to the pandemic may help dyslexic students because they can review recorded lectures at their own pace. For businesses, the Welsh Government has a bilingual technology toolkit (https://gov.wales/bilingual-technology-toolkit-good-user-experience) and in the voluntary sector, the Welsh Language Commissioner offers a free bilingual proofreading service for text up to 1000 words.

In summary, bilingual students may need more time to read, write and proof read their work. Note-taking and copying from the board may be more difficult and they may fall behind in their coursework and find they have incomplete notes when they start to revise for examinations. These students may be slower in writing answers during examinations in both written English and in calculations if they translate from Welsh into English and then write their answer.

These findings provided the motivation for the current study, which aimed to evaluate the speed and accuracy of performance on the Wordchain test of silent reading in Welsh speaking dyslexic university students in comparison with control students reading in both Welsh and English. It was predicted, based on evidence from earlier studies that the

Welsh speaking dyslexic students would be slower in their performance, and the results would provide confirmation of whether or not their speed issues relate to the need to translate into English, or whether there are specific underlying difficulties with efficiency in Welsh language tasks.

METHOD

Measures

The Wordchains test (Miller Guron, 1999) is a test of silent reading speed based on segmentation of words presented in clusters of 3 or 4 without spaces. The task demands that the participants complete the segmentation using pencil and paper to place a slash between each word e.g. sandcoffeeblue - sand/coffee/blue or in Welsh tywodcoffiglas tywod/coffi/glas. An expert evaluated the original word base, and translated the words directly from English to Welsh. To give an example:

the chain saladnursebakerdaisy should be segmented as salad/nurse/baker/daisy with the Welsh equivalent saladnyrspobyddllygadydydd segmented as salad/nyrs/pobydd/llygadydydd
The word daisy = llygad y dydd, and is notably longer than the English word.

The Questionnaire

This was developed in order to evaluate the level of Welsh contribution to each participant, including the home language and the time frame within which Welsh had been spoken. See Appendix 1 for the full questionnaire.

The Pilot Study

18 pilot study participants self-identified from a list of HE students who had agreed, in principle, to take part in research into dyslexia during their studies. All students undertook a Wordchains test in English or Welsh depending on the language spoken. In addition, 3 Welsh students took the Wordchains test in English.

16 students completed the questionnaire after the test: 8 dyslexic and 8 non-dyslexic students. 12 students were in the 18-21 age range and 4 were mature students.

Only students who were English speakers or bilingual Welsh and English speakers were accepted as participants in the study. All dyslexic students had a formal diagnosis of dyslexia by an Educational Psychologist or a Qualified Specialist Teacher in line with the guidelines for the Disabled Students Allowance. 8 were bilingual Welsh and English speakers and 8 were English speakers only. Of the 8 dyslexic students, 3 were bilingual Welsh and English speakers and 5 were English speakers. Of the non-dyslexic students,

5 were bilingual Welsh and English speakers and 3 were English speakers. 9 students identified themselves as female and 7 as male.

One participant was interviewed.

Conclusions of the Pilot Study

The results of the Pilot Study indicated that Welsh speaking students were slower at completing the Wordshains test in Welsh. This may have been due to the increased number of characters in the Welsh version of the test which was directly translated from the English corresponding to a greater difference in the length of the Wordchains.

Dyslexic Welsh speaking students were particularly slow completing the English Wordchains compared to English speaking Dyslexic students. English speaking non-dyslexic students and Welsh speaking non-dyslexic students all scored comparably on the English Wordchains test.

Gender Differences in Welsh Wordchains Mirrored those in English Wordchains

Aled, a Welsh speaking bilingual student, who was interviewed, described himself as "immersed in Welsh". Spelling and punctuation were difficult for him in both Welsh and English. He said that Welsh had no hidden letters and it was pronounced the way it was spelled, but in English there are silent 'k's and 'e's etc, so English was difficult for him. Aled was concerned that there are few tests (for dyslexia) in Welsh and for children this is important whereas he considered being tested as adult in English is acceptable. He felt that if his daughter, who attends a Welsh-language school, was tested for dyslexia in English it would be unfair, but not if she was tested in Welsh.

Modifications of the Pilot Study

Based on the results of the pilot study, it was decided to aim for a minimum of 20 students in each of the four groups: Welsh speaking Dyslexic and Non-Dyslexic students, and English speaking Dyslexic and Non-Dyslexic students. The students involved in the pilot study did not participate in the main study and the participants self-identified in the same way as in the pilot study. Again, only students who were mono-lingual English or bilingual Welsh/English were invited to take part. Only dyslexic students with a formal dyslexia diagnosis were admitted to participate in the study. All controls completed the Adult Checklist screener and those non-dyslexic students who were 'at risk' were not invited to participate in the study.

The initial part of the Wordchains test, Letterchains was changed to include Welsh letters. In addition, the Welsh Wordchains test was modified to have parity of character length between Welsh and English versions of the test.

Study 1. Bilingualism and Dyslexia: Evaluation using a Revised Wordchains Matched for Length.

A revised Welsh Wordchains test, with stimuli matched for overall word length with the English test was administered to bilingual Welsh speaking students in Higher education, A questionnaire was also administered to all participants, designed to elicit any differences experienced in processing in Welsh and English (see Appendix 1 for this questionnaire). This would provide both qualitative and quantitative support for the relative speed and difficulty of performance in Welsh and English. All Welsh speaking bilingual students were asked if they would be interviewed and one participant agreed in order to provide the case study below.

Participants

The sample consisted of 14 Welsh speaking Dyslexic students, 25 Welsh speaking Non-Dyslexic students, 24 English speaking Dyslexic students and 25 English speaking Non-Dyslexic students giving a total of N=88.

Results

64 female students took part in the study and 24 male students. 38 dyslexic students and 50 non-dyslexics, see Table 3.

Table 3. Male/female participants in the dyslexic and control groups

Count	Gender		Total
	Female	Male	
Dyslexic	28	10	38
Non-Dyslexic	36	14	50
	64	24	88

77 participants took the English Wordchains test, 56 female and 21 male. There was no significant difference between the mean scores obtained by female or male students, see Figure 2.

Figure 1 shows that non-dyslexic students had higher scores in the English Wordchains than the dyslexic students, of the latter, the English- speaking dyslexic students performed better than the Welsh students.

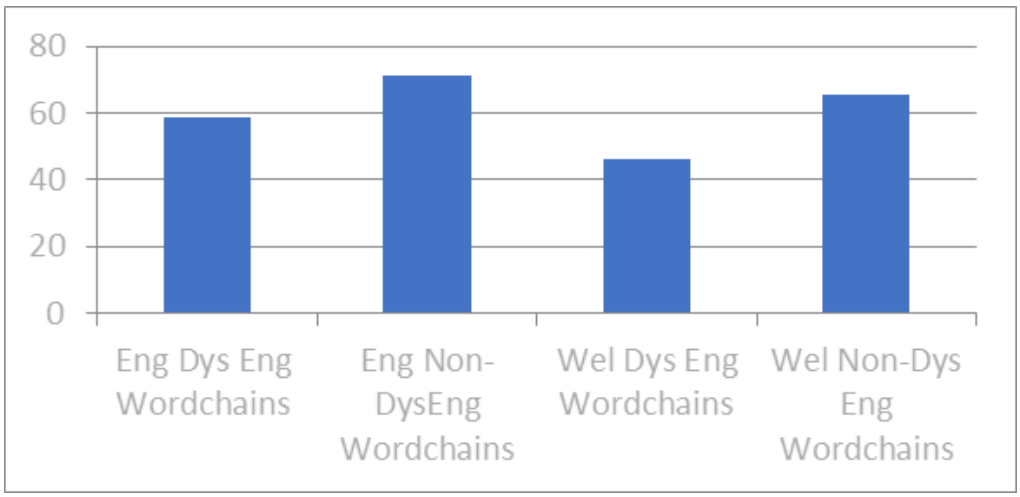


Figure 1. Mean scores of students taking the English Wordchains test against language and dyslexia

It is interesting to note that Welsh speaking non-dyslexic students achieved comparable scores to those of English dyslexic students. However, there was tremendous variability in the scores as seen in Table 4. This could be due to a basic difficulty with reading but Figure 2 shows that Welsh speakers whether dyslexic or not show the greatest difficulty.

Table 4. The Range of Raw Scores achieved by students undertaking the English and Welsh Wordchains, mean scores and standard deviations.

Language v Dyslexia	Range of Raw Scores	Mean	N	Standard Deviation
English Wordchains				
English Dyslexic Students	25-90	58.92	25	14.28
Welsh Dyslexic Students	22-65	46.07	14	15.79
English Non-Dyslexic Students	40-89	70.91	22	11.88
Welsh Non-Dyslexic Students	54-83	66.88	17	11.54
Welsh Wordchains				
Welsh Dyslexic Students	14-32	22.71	14	5.4
Welsh Non-Dyslexic Students	15-50	34.92	25	9.18

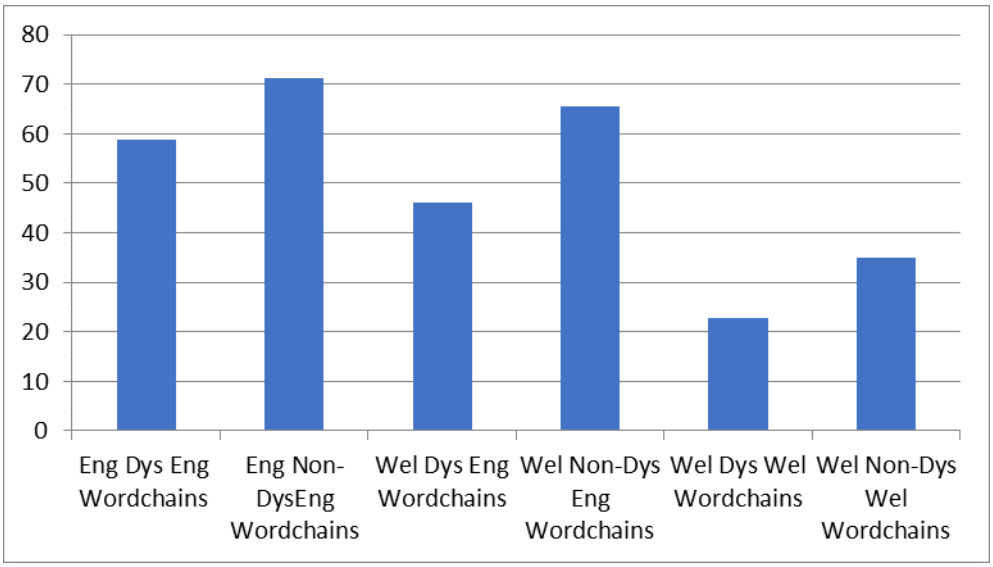


Figure 2. Raw Scores of English and Welsh Wordchains

The number of Wordchains correctly scored form the dependent variable and the independent variables are language (monolingual English or Welsh Bilingual) and Dyslexic or Non-dyslexic

An analysis of variance (ANOVA) test was undertaken on the English Wordchains scores indicating that there was a significant difference between the groups F=11.06 p <.001; see Table 5

Table 5. Comparison of scores for the impact of language and dyslexia

English Wordchains (means in groups)	
Language v Dyslexia	**Significance**
English Dyslexics v Welsh Dyslexics	0.048*
English Dyslexics v English Non-Dyslexics	0.030*
English Dyslexics v Welsh Non-Dyslexics	0.317
Welsh Dyslexics v English Non-Dyslexics	0.000**
Welsh Dyslexics v Welsh Non-Dyslexics	0.001**

*Values at 0.05 and 0.001 significance

At this level of significance (>.001) there would be a less than 1% chance of the difference between the variables occurring by chance.

Analysis of the Questionnaire.

The results of the questionnaire were tabulated and a series of chi square tests performed in order to identify any significant differences between the dyslexics and the non-dyslexics. The following results indicate the impact that dyslexia and bilingualism can continue to have on students in HE.

I. Is Reading Tiring?

The answer was yes if you are dyslexic, with a significant difference between the dyslexics and controls.

Table 6. A crosstabulation of Dyslexia against 'Is Reading Tiring?'

		Is Reading Tiring?		Total
		Yes	**No**	
Dyslexia	**Dyslexic**	27	11	38
	Non-Dyslexic	12	38	50
Total		**39**	**49**	**88**

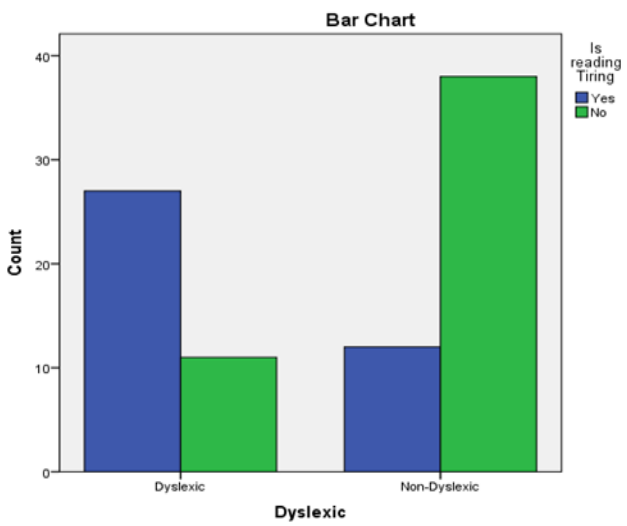


Figure 3. Bar chart of dyslexic and control responses to is reading tiring?

A chi square test indicated that this result was significant, n=88,df 1, X^2

19.37, p = <.001. Thus, suggesting that dyslexic students found reading significantly more tiring than non-dyslexic students.

II. Is Writing Easy?

A chi square test indicated that this result was significant, n88, df 1, X^2 13.7 p<.001, see Table 7

Table 7. A crosstabulation of Dyslexia against 'Is Writing Easy?'

		Is Writing Easy?		Total
		Yes	No	
Dyslexia	**Dyslexic**	14	24	38
	Non-Dyslexic	38	12	50
Total		**52**	**36**	**88**

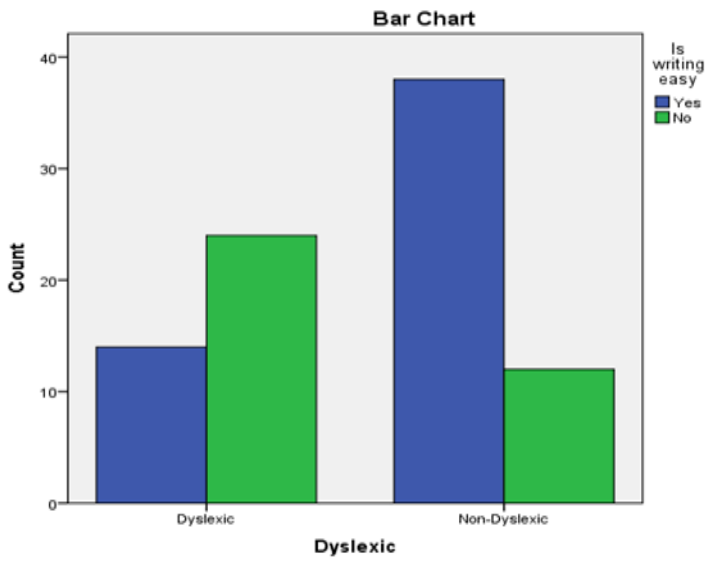


Figure 4. Is writing easy?

Thus the results suggest that dyslexic students found that writing was significantly more difficult than non-dyslexic students.

Participants were also asked in which language they made more errors and whether they translated from Welsh to English while writing. Neither of these questions produced significant results.

Case Study of a Welsh Dyslexic Student

One Welsh speaking dyslexic student agreed to be interviewed.

Daffyd was a first language Welsh speaking bilingual student reading science. Both his parents spoke Welsh in the home until he was in primary school when his father changed jobs and then tended to speak English. English Television and radio were watched and listened to but Daffyd was educated through the medium of Welsh from nursery school until he reached university. He spoke Welsh to the teachers and in formal situations at school but English to his friends. He used and still uses English for speaking on the mobile phone or texting except to his Mother. In his university flat, he speaks mainly English but his flatmates are bilingual and he can speak fluently in either language.

He was taught mathematics through the medium of Welsh until university although he had an English mathematics tutor for the latter part of his A Level to help him revise. He did not feel that he had difficulty learning English or Welsh although the mutations were difficult to learn in Welsh and it was hard to spell and use correctly the 'easy' words in English, for example, 'were' and 'where'. He studied Welsh and English GCSE (Language and literature).

Until A level he approached mathematics through the medium of Welsh, but his English mathematics tutor helped him to learn some of the language of mathematics in English. In the first semester at university, he struggled with the English terms in mathematics, for example, 'differentiation'.

Daffyd was first assessed for Dyslexia at 18 years although as a child, his parents suspected he had a Specific Learning Difficulty. In the first semester at university work was nearer to A Level, and so it was easier for him to connect terms in lectures, but when new topics started to be introduced it became a steeper learning curve. When answering assignment questions, he needs to Google definitions but can "get lost in the question... He cannot get the context of the question." He stated that "I think in Welsh but when following the procedure [in mathematics] I think in English which is probably the influence of the English mathematics tutor". If there are multiple terms he does not know, he will struggle with the question.

When revising he spent time trying to understand the language of as many past papers as possible. He found it easier to decipher a complicated word in English because "I can break it down more easily than a complicated word in Welsh". In exams, Daffyd reported that, "I can skim over words because I'm dyslexic, and I can miss a word like 'not' and then I'll have to cross work out and redo it, and I struggle with punctuation."

He also reported that, "When speaking Welsh, I think through the medium of English and I'll think of my sentences in English, so it takes time to translate." When completing the

Welsh Wordchains test he stated that, "if he didn't know the words because of the dialect or how the mutations were applied, it was easier to work from the end of the chain forwards to find a break". This implies that Daffyd was using a process of logic rather than an automatic reading process to identify the individual words in a chain.

DISCUSSION

The results of this study indicated that even when words were matched for word length, the Wordchains test was more difficult in Welsh for both Dyslexic and Non-dyslexic students. Welsh speaking bilingual dyslexic students achieved the poorest scores followed by Welsh speaking controls in comparison to the results for the English test equivalent overall in agreement with Spencer and Hanley (2003) that any advantage learning Welsh as a first language may confer is lost after the age of 10 years when Welsh grammar becomes more complex. The questionnaire study also provided further evidence that dyslexic students still found reading tiring, and that writing was not easy for them. The difficulties encountered were reinforced by a rich case study that provided further evidence of the confusion that can arise when a dyslexic student, even one of high ability, learns in one language and uses another language in Higher Education. This is particularly true when the subject studied includes a range of terms that may not be familiar in the 2nd language.

In terms of teaching Welsh as a subject more widely within Wales, it is clear that Welsh itself can be a challenge for all students, but more specifically for dyslexic students. Nevertheless, it could also be argued that the benefits of bi-lingualism, whether in Welsh or other languages, impact on the refinement of executive function and provide some protection into old age instead Alzheimer's disease (Bialystok et al., 2012). However, more recently, this finding has been challenged by a metanalysis from Lehtonen and colleagues (Lehtonen et al., 2018), which found no statistically significant evidence for this view. However, it seems self-evident that a rich language background such as that encountered in many bilingual households, should lead to enhanced skills in language. Whether or not this holds true for students with dyslexia is not yet clear.

In terms of Welsh speaking students, there is a clear need internationally to maintain minority languages that have been in danger of dying out. No-one would suggest that this is not a worthy consideration. However, it might well be argued that Welsh speaking students would benefit from extra time in their examinations when they are asked to process in English, whether or not they are dyslexic. There is of course, a compelling case for providing extra time for dyslexic students, in whichever language they process. The UK system is currently one of the best in providing recognition for dyslexia and other conditions that might impact on progress in examinations. A speed deficit, whatever the cause, has recently been recognised as justification for the provision of extra time in school examinations, with the school themselves able to provide evidence to this effect through specialist teachers.

Unfortunately, this allowance of extra time is not provided as a right in many countries across the world, and in Asia provision of support at this level is varied. Moreover, support throughout schooling can also be variable, with some outstanding exceptions. The findings from the case study are particularly important, because bilingual dyslexic students may well suffer from unexpected difficulties with vocabulary when processing in English, if they have previously studied in their native language. Furthermore, provision of support is still not a right, and can remain expensive and restricted in access in many countries.

LIMITATIONS AND DIRECTIONS FOR FURTHER RESEARCH.

This study, although well designed and executed remains relatively small and there is no doubt that further research in this area is needed. A larger scale study would be useful, as well as a study of younger participants at secondary level, to see whether or not the same pattern of results pertains.

The Wordchains test, which is available for translation into a range of languages (with permission from the author) could be a key to progress across a range of studies of bilingualism.

CONCLUSIONS

A study of bilingual Welsh speaking students showed that Welsh students with dyslexia were particularly slow, even when stimuli were matched for word length. Interestingly, non-dyslexic Welsh speakers were also slow, although not as slow as their dyslexic counterparts. Moreover, despite the known speed deficits associated with dyslexia, the performance of the non-dyslexic Welsh speakers was equivalent overall to the dyslexic English speakers, suggesting a gradation in difficulty level with the Welsh dyslexic most severely affected, but even the non-dyslexic Welsh speakers showing mean speed levels that matched the English-speaking dyslexic. However, there was considerable variability within this pattern of results, with some English-speaking dyslexics showing more extreme results than others. Implications for bilingual students more generally were discussed and Wordchains recommended as a suitable vehicle for examining speed differences between languages.

ACKNOWLEDGEMENTS

GLAssessments for permission to translate and administer the test Wordchains .

REFERENCES

Bialystok, E., Craik, F. I., & Luk, G. (2012). Bilingualism: Consequences for mind and brain. *Trends in Cognitive Sciences, 16*(4), 240-250. http://doi.org/ 10.1016/j.tics.2012.03.001

Caravolas, M., Volin, J., & Hulme, C. (2005). Phoneme Awareness Is a Key Component of Alphabetic Literacy Skills in Consistent and Inconsistent Orthographies: Evidence from Czech and English Children. *Journal of Experimental Child Psychology, 92*, 107-139.

Caravolas, M., Lervag, A., Mousikou, P. et al. (2012a). Common patterns of prediction of literacy development in different alphabetic orthographies. *Psychological Science, 23*, 678-686.

Cartmill, M. (1976), Surface Phonology and Underlying Forms, Linguistic Inquiry, 7(4), 675-677.

Cavalli, E, Casalis, S., El Ahmadi, A., Zira, M., Porrachia-George, F., & Cole, P. (2016). Vocabulary skills are well developed in university students with dyslexia. *Research in Developmental Disabilities, 51-52*, 89-102.

Cline, T. (2000). Multilingualism and dyslexia: Challenges for research and practice. *Dyslexia, 6*, 3-12.

Cogan, P. (2000), *The Dyslexic Student at College*, paper presented to a one-day Conference on Staff Development, The Dublin Institute of Higher Education, Dublin, April.

Dyslexia Wales. (2009), *The Adult Checklist*, accessed on 28th June, 2010 from: http:// www.welshdyslexia.info/

Egan, C., Oppenheim, G. M., Savile, C. Moll, K., & Wyn Jones, M. (2019). Bilinguals apply language-specific grain sizes during sentence reading. *Cognition, 193*, 104018.

Elander, J., Harrington, K., Norton, L., Robinson, H., Reddy, P., (2006), Complex skills and academic writing: a review of evidence about the types of learning required to meet core assessment criteria, *Assessment & Evaluation in Higher Education, 31*, 71 – 90.

Ellis, N. C., & Hooper, A. M. (2001). Why learning to read is easier in Welsh than in English: orthographic transparency effects evinced with frequency-matched tests. *Applied Psycholinguistics, 22*,571–599.

Ellis, N. C., & Hennelly, R, A., (1980), A bilingual word-length effect: Implications for intelligence testing and the relative ease of mental calculation in Welsh and English, *British Journal of Psychology, 71*, 43 – 51.

Elbeheri, G., Everatt, J., & Al Malki, M. (2008). The incidence of dyslexia among young offenders in Kuwait. *Dyslexia, 15*, 86-104.

Evans, B. J. W., (2001), *Dyslexia & Vision*, London, Whurr.

Fawcett, A. J. (2000). Dyslexia and learning. Theory into practice. In L, Peer. G. Reid, (eds) *Multilingualism, Literacy and Dyslexia Peer*. Routledge, Oxfordshire.

Frost, R., Siegelman, N., Narkiss, A., & Afek, L. (2013). What predicts successful literacy acquisition in a second language? *Psychological Science, 24*, 7 ,1243–1252.

Garcia-Sierra, A., Rivera-Gaxiola, M., Percaccio, C.R. et al. (2011). Bilingual language learning: an ERP study relating early brain responses to speech, language input, and later word production. *Journal of Phonetics, 39*, 4, 546–557.

Gathercole, V. C. M., & Thomas, E. M. (2005). Minority Language Survival: Input Factors Influencing the Acquisition of Welsh, *Proceedings of 4th International Symposium on Bilingualism*, J. Cohen, K. T. McAlister, K. Rolstad, & J, MacSwan (eds), 852 – 874, Sommerville, MA: Cascade Press.

Gauntlett, D., (1990). Managing the dyslexic adult, In G. Hales, M., Hales, T, Miles, & A., Summerfield, (eds), *Meeting Points in Dyslexia*, pp 240 – 4, Reading, British Dyslexia Association.

Gilroy, D.E., (2004). Stress factors in the college student, in T. R. Miles (ed), *Dyslexia and Stress*, London, Whurr.

Hanley, J. R., Masterson, J., Spencer, L. H. and Evans, D. (2004). How long do the advantages of learning to read a transparent orthography last? An investigation of the reading skills and reading impairment of Welsh children at 10 years of age. *The Quarterly Journal of Experimental Psychology Section A, 57*, 1393–1410.

Jackson, N. E., (2005), Are university students' component reading skills related to their text comprehension and academic achievement? *Learning and Individual Differences, 15*, 113 – 139.

Jones, N., & Fawcett, A. J. (2013). Screening children with dyslexia in South Wales. In *Dyslexia Handbook.* Reading: BDA.

Kelly, K. (2002). *The early detection of dyslexia in bi-lingual pupils*. Unpublished PhD thesis. Manchester Metropolitan University.

Kuhl, P. K. (2004). Early language acquisition: cracking the speech code. *Nature Reviews Neuroscience, 5*, 11, 831–843.

Lallier, M., Valdois, S., Lassus-Sangosse, D., Prado, C., & Kandel, S. (2014). Impact of orthographic transparency on typical and atypical reading development: evidence in French–Spanish bilingual children. *Research in Developmental Disabilities, 35*, 1177–1190.

Lallier, M., & Carreiras, M.(2018). Cross linguistic transfer in bilinguals reading in two alphabetic orthographies: the grain size accommodation hypothesis. *Pysch. Bull Rev. 25*, 386-401.

Lehtonen, M., Soveri, A., & Laine, A. (2018). Is bilingualism associated with enhanced executive functioning in adults? A meta-analytic review. *Psychological Bulletin*. pp. 394-425. ISSN 0033-2909

Lindgren, S.-A., & Laine, M. (2007). The adaptation of an adult group screening test for dyslexia into Finland-Swedish: Normative data for university students and the effects of language background on test performance. *Scandinavian Journal of Psychology, 48*, 419–432.

Lindgren, S.-A., & Laine, M. (2010). Cognitive linguistic performances of Multilingual University students suspected of dyslexia. *Dyslexia, 17*, 184-200.

Mateos, M., Villalón, R., de Dios, M. J., & Marin, E., (2007). Reading and writing tasks on different university degree courses: what do students say they do? *Studies in higher Education, 32*, 489 – 510.

Mayer, P., Crowley, K., & Kaminska, Z. (2007). Reading and spelling processes in Welsh–English bilinguals: differential effects of concurrent vocalisation tasks. *Reading and Writing: An Interdisciplinary Journal, 20*, 671–690.

McDougall, S., & de Mornay Davies, P., (2010) The Development of Reading Skills in Different Orthographies: An introduction and overview, 3-21 in *Reading and Dyslexia in different Orthographies.* Nicola Brunswick, Sine McDougall and Paul de Mornay Davies (ed), Psychology Press, London

Meehan, M. (2011) Welsh, bilingualism and dyslexia. *Journal of Inclusive Practice in Further and Higher Education. 3.* pp. 51-62

Miller Guron, L. (1999). *Wordchains: A word reading test for all ages*. Windsor: NFER-Nelson.

Miller-Guron, L., Lundberg, I. (2000). *Dysl*exia and second language reading: A second bite at the apple?. *Reading and Writing 12*, 41–61 https://doi.org/10.1023/A:1008009703641

Miller-Guron, L., & Lundberg, I. (2004). Error patterns in word reading among primary school children: a cross orthographic study. *Dyslexia, 10*, 44-60.

Mortimore, T., & Crozier, W. R., (2006), Dyslexia and difficulties with study skills in higher education, *Studies in higher Education, 31*, 235 – 251.

Mortimore, T., Hansen, L., Hutchings, M., & Northcote, A. (2012). Dyslexia *and multilingualism: Identifying and supporting bilingual learners who might be at risk of developing SpLD/ dyslexia.* British Dyslexia Association research report.

Nicolson, R. I, Fawcett, A. J, Brookes, R. L., & Needle J. (2010). Procedural learning and dyslexia. *Dyslexia, 16*, 194-212

Pavey, B., Meehan, M., & Waugh, A., (2010). *Dyslexia-Friendly Further & Higher Educatio*n, Sager, London.

Richardson, J. T. E., & Wydell, T. N., (2003), The representation and attainment of students with dyslexia in UK higher education, *Reading and Writing, 16*, 475 – 503.

Smith-Spark, J. H., Henry, L. A., Messer, D. J., Edvardsdottir, E., & Zięcik, A. P. (2016). Executive functions in adults with developmental dyslexia. *Research in Developmental Disabilities, 53-*54 pp. 323–341.

Spencer, L. H., & Hanley, J. R. (2003). Effects of orthographic transparency on reading and phoneme awareness in children learning to read in Wales. *British Journal of Psychology, 94*, 1–28.

Spencer, L. H., & Hanley, J. R. (2004). Learning a transparent orthography at five years old: reading development of children during their first year of formal reading instruction in Wales. *Journal of Research Reading, 27*, 1–14.

Strand, S., Malmberg, L., & Hall, J. (2015). *English as an Additional Language (EAL) and educational achievement in England: An analysis of the National Pupil Database*. https:// educationendowmentfoundation. org.uk/uploads/pdf/ EAL_and_educational_achievement2.pdf

Wilkins, A., (2003), *Reading Through Colour*, Chichester: John Wiley & Sons Ltd.

Ziegler, J.C., & Goswami, U. (2005). "Reading acquisition, developmental dyslexia, and skilled reading across languages: a psycholinguistic grain size theory." *Psychol Bull 131*(1):3-29

APPENDIX

Welsh, Dyslexia and Bilingualism Questionnaire			
This questionnaire is in two parts. Part I deals your experience of reading and writing, and Part II asks for some personal details. Please complete both parts			
Part 1			
1	Do you find reading tiring?	Yes	o
		No	o
2	Is writing easy for you?	Yes	o
		No	o
3a	Is Welsh your first language?	Yes	o
		No	o
b	Is English your first language?	Yes	o
		No	o
4	Is your level of spoken Welsh:		
	fluent?		o
	Intermediate?		o
	beginner?		o
	None of the above?		o
5a	Do you speak Welsh at home?	Yes	o
		No	o
b	Do you speak Welsh at college?	Yes	o
		No	o

6	Is your level of written Welsh:		
		fluent?	o
		Intermediate?	o
		beginner?	o
		None of the above?	o
7a	Do you think mainly in English?	Yes	o
		No	o
b	Do you think mainly in Welsh?	Yes	o
		No	o
8a	Do you dream mainly in Welsh?	Yes	o
		No	o
b	Do you dream mainly in English?	Yes	o
		No	o
9a	Do you take longer to read in English?	Yes	o
		No	o
b	Do you take longer to read in Welsh?	Yes	o
		No	o
10	Do you text/email in Welsh?	Yes	o
		No	o
11	When writing in English do you find yourself translating from Welsh?	Yes	o
		No	o
12a	Do you find you have more errors in your written Welsh?	Yes	o
		No	o
b	Do you find you have more errors in your written English?	Yes	o
		No	o

13a	What kind of errors do you make in written English?		
b	What kind of errors do you make in written Welsh?		
Part 2			
Please could you fill in some details about yourself.			
14	Your age: 20-30 O 31-40 O 41-50 O 51-60 O 61-70 O		
15	Are you: Male O Female O		
16	Which subject and qualification do you hope to gain, e.g. BA. Nursing, BEng (Civil) etc.		
17a	Do you have a qualification in Welsh, e.g. GCSE?	Yes	O
		No	O
	Which qualification?		
b	Do you have a qualification in English, e.g. GCSE?	Yes	O
		No	O
	Which qualification?		
18	Were you taught trough the medium of Welsh at:		
	Nursery		O
	Primary School		O
	Secondary School		O
	College/Further Education		O
	Higher Education		O
	None of the above		O
19	Do you have an assessment of dyslexia?	Yes	O
		No	O

20	When were you assessed	
	Primary School	o
	Secondary School	o
	College/Further Education	o
	Higher Education	o
21	Have you received support for dyslexia at:	
	Primary School	o
	Secondary School	o
	College/Further Education	o
	Higher Education	o
Thank you for taking the time to complete this questionnaire		

Asia Pacific Journal of Developmental Differences
Vol. 10, No. 1, January 2023 pp. 161—182
DOI: 10.3850/S2345734123000711

Long-term Management of Dyslexia: A Case Report of Social Emotional Problems in Dyslexia

Rima Natasha Hartanto[1*], Dyah Ayu Palupi[1], Ersita Sari[1] and Ayu Yowanda[1]

1 *Dyslexia Association of Indonesia*

Abstract

Dyslexia may often be confused with other conditions, especially in people with dyslexia with behavioural complaints and social language disorders. Those who have difficulty interacting are often diagnosed with autism or other autism spectrum disorders such as Asperger's. In this case report the journey is described of a dyslexic boy, whose social language disorder was difficult to change over time. Louis (not his real name) was first diagnosed as dyslexic at the age of 9 years and 11 months. There followed various comprehensive interventions related to aspects of spoken language, written language, social language, and most importantly behavioural and social emotions, described in this case study. The importance of comprehensive diagnoses is emphasized, in order to identify all aspects of the difficulties that may be encountered by each individual child.

Keywords: Dyslexia, behaviour, Autism Spectrum Disorder (ASD), Asperger's Syndrome, Social Language Disorder, Assessment, Diagnosis

* *Correspondence to:*
Dr Rima Natasha Hartanto, Dyslexia Association of Indonesia. Email: rima_natasha@yahoo.com

BACKGROUND

In Indonesia, awareness of Dyslexia has been increasing over the last 10 years. More parents bring their children to a professional at different ages, with various problems and comorbidities. Dyslexia has become a burden in primary education, due to its complicated and varied conditions. Dyslexia is a disorder of the language system, more specifically, within a particular subcomponent of the system, phonological processing. (Saltz, 2017)

The Dyslexia definition by the Dyslexia Association of Indonesia has expanded not only in recognizing reading problems. The Dyslexia Association of Indonesia has stated that dyslexia is one form of specific learning difficulties, which is a condition characterized by learning difficulties that occur in individuals with intelligence potential that is at least normal or at the average intelligence level, where learning difficulties that occur include difficulties in language areas, including language. These include Verbal (which is mainly characterized by impaired phoneme awareness), written language, and social language (difficulty interpreting body language, attitudes, and postures), and difficulty displaying appropriate body language, attitude, and posture in response to a social situation), accompanied by disturbances in the area of executive function. Dyslexia is also often accompanied by other forms of specific learning difficulties, namely dysgraphia, and dyscalculia. In addition, dyslexia is often accompanied by other concomitant conditions such as Attention Deficit Hyperactivity Disorder and Motor Planning Disorder (Dyspraxia). (Solek & Soegondo, 2018) (Dyslexia Association of Indonesia, 2019).

Social language problems are often conveyed in various terms by parents, for example, shyness, not wanting to meet people, and being attached to parents. Parents assume this is a normal process in development. In the Social-Emotional-Personal development milestones based on the Griffith III Developmental assessment scale at the age of 3-4 years, a child should be able to separate easily from their parents. This age range (3-4 years) is equal to nursery in Indonesia, where most children go to school for 2-3 hours per day.

Expressive language disorders are known as predictors of learning difficulties in later life. This condition is easily notified and instantly taken care of by speech therapy sessions. But professionals or education administrators often miss information about the social language. The inability of a child to adapt to a new social situation can lead to attachment behaviour, emotional fluctuation, shouting, crying, and other challenging behaviour. In DSM V, social (pragmatic) communication disorder is described as persistent difficulties in the social use of verbal and nonverbal communication. (Association, 2013) In fact, if we further examine language processing (both spoken, written, and social language) in dyslexia, the symptoms of social communication disorder can be found in dyslexic individuals. As stated by Reid, the early years of dyslexia also show social-emotional problems that are often overlooked by parents and educators.

(Reid, 2017). Symptoms that can appear include easy frustration, difficulty in separating from parents, children often feeling uncomfortable, and often crying for a long time.

This case report aims to provide an overview of the management of dyslexic children who have severe social language disorders, and have received the intervention after reaching the age of 9 years. Conditions that are identified very late make it difficult to improve social behaviour.

First Look at Louis

Louis (not his real name) first came to our clinic at the age of 9 years and 11 months in 4th grade. The chief complaint from his mother was looking for the answer to what had happened to Louis. At the age of 3, Louis was not able to separate easily from his mother, had a language delay, and was uneasy following instructions at school. Louis was not diagnosed with dyslexia until he reached 9 years old. He has had difficulty socializing.

After going into therapy sessions from the age of 3, at the age of 6, his mother was told that Louis had passed all the necessities to enter school and he needed no further therapies. Even though it was stated no further therapy, the mother felt that there was something lacking in Louis's performance. At school, he is in 4th grade, very lazy to study, prefers multiple choice questions rather than essays, often says he is dizzy while studying, has difficulty making friends, feels uncomfortable easily, and gets angry easily. Children like Louis are often seen clinging to their mothers in public spaces.

In the first meeting, he did not look at the other person, and he had difficulty conveying the content of his thought, Louis had interaction skills, did not see autistic movements, and he was able to listen to instructions. When asked to enter without their parents, children need to be persuaded and often hide behind walls.

During the first assessment, it was found based on observations that Louis's attitude was not confident, indicated by not looking at the other person. When doing tasks Louis looks restless, shifts in the chair repeatedly, finds it difficult to sit up straight, and often puts his head on the table.

The diagnosis of dyslexia was concluded from observations, interviews with parents and children, and clinical assessments. In his early years, Louis was reported to have a lack of attention, was uneasily separated from his parents, and was not easy to follow instructions from preschool teachers. This is consistent with the description of the risk of dyslexia as described by Reid, 2017.

Assessment of dyslexia is a process that involves more than just using a single test. (Reid, 2011). The behavioural aspect is certainly an early observation, considering the many

comorbidities between dyslexia and behavioural problems such as ADHD, anxiety disorders, conduct disorder, and Oppositional defiant disorder. Louis showed unwillingness to look directly into the examiner's eyes, but Louis turned his face towards the examiner. When examined, Louis showed an uneasy attitude, repeatedly shifting from his seat, putting his head on the table, and rushing to do his assignments. The attitude shown is in accordance with the description of ADHD (predominantly inattentive). Dyslexia is also inseparable from executive function disorders. Executive function components such as cognitive flexibility, inhibition control, and weak working memory were seen during the assessment. Lous couldn't help but growl at a difficult answer. Louis didn't ask questions when he ran into trouble. The difficulties found could be identified ,but Louis did not express these difficulties verbally. After being given the opportunity to find the wrong answer, Louis needs to be given direction to find the right answer.

In the literacy assessment, Louis' reading ability was not according to his age of 9 years. There are several sight words in Indonesian that cannot be read. Louis has difficulty combining 4 or more syllables, for example, Indonesian verbs use affixes.

The following is a reading and writing checklist used in Louis's assessment.

Checklist Reading	**Comments**
Sight vocabulary	Unread, missed
Sound blending	Changed to a different sound
Use of contextual cues	Not understood
Attempting unknown vocabulary	Tried to read but slower rate
Eye tracking	The title between paragraphs isnot read
Difficulty keeping place	Yes
Speech development	New words that are not understood tend to be read in a mumble
Word naming difficulty	Yes
Omitting words	Yes
Omitting phrases	Yes
Omitting whole lines	Yes
Attention to punctuation	No
Reading intonation	Not variable
Comprehension	Difficult to memorize character names, events, places, and times that occurred in the story

Checklist Writing	**Comments**
Directional Difficulty	Not Found
Proportional	Disproportionate font size and shape
Ascender/descender	Descender letter (j, y, p) too short
Spacing	Too wide space
Handwriting difficulty	Yes
Difficulty with cursive writing	Yes
Using capital and lowercase interchangeably and inconsistently	Yes
Poor organization of work on page	Yes, Writing is too big in a small writing space. The spacing is too wide
Incoherent slope	Floating letters on plain paper
Vocabulary in writing	Limited
Organization of stories	Not coherent, not using correct conjunctions

During the assessment, Louis also has not memorized the names of the months in the year, including writing the name of the month. In math word problems, children seem to have difficulty working on story problems. The technique of counting down in addition has not placed the units and tens correctly. Correction of wrong answers needs to be repeated several times for Louis to understand.

These findings are also complemented by findings in the area of mathematics. In working on a math problem, Louis incorrectly places the units' results in the tens. Louis had difficulty understanding math word problems with more than one piece of information. Louis had difficulty changing sentences in word problems into mathematical operations. Louis also had difficulties in understanding fractions, difficulties in remembering multiplication, and in division operations. Observation during the assessment also revealed that Louis had difficulty mastering arithmetic facts by traditional methods, learning concepts of time and wind direction, trouble reading simple maps, and remembering facts for word problems and formulas for completing mathematical calculations. While solving math problems, Louis uses an arithmetic procedure that is immature and inefficient and has problems in sequencing steps of multistep procedures. He also makes frequent mistakes when using procedures.

Louis was observed to have poor posture, uneasy sitting upright, and leaning on a wall or table, or pole while standing. Performing motoric coordination activities such as standing on one foot, jumping with 2 feet and landing together, and catching and throwing a ball, produced a very clumsy performance from Louis.

During assessment and in the early intervention in remedial teaching, Louis showed a pattern of angry or irritable mood, defiant behaviour, and exhibited during interaction with at least one individual who were not siblings.

Then Louis takes an IQ test with a total IQ of 99, verbal IQ of 95, and Performance IQ of 104. From the results of this intelligence, the scores that were lacking are self-adjustment, self-confidence, and understanding of the rules. While the less value is the understanding of social values. And some have good scores, which are knowledge insight and analysis-synthesis. Intelligence test results that show differences in verbal ability and performance show that Louis has average intelligence with poor language performance. This is consistent with the description of the results of intelligence tests on dyslexia.

A diagnosis of Specific Learning Difficulty (Dyslexia, Dysgraphia, and Dyscalculia), comorbid ADHD along with Opposition defiant disorder, and Developmental Coordination Disorder was concluded.

First 6 months

First Louis was given therapy in individual sessions. This therapy aimed to manage learning readiness and emotional response, and increase interaction and expression. and in particular to train executive functions in learning, namely rushing to work on assignments, identifying mistakes, and correcting wrong answers. In individual therapy, a literacy program was given, namely answering questions according to what is read, correcting writing, improving how to hold a pencil, understanding word problems in math, and functional mathematics such as counting money, changing, discounted prices, etc.

In individual therapy, a very stooped posture, difficulty maintaining an upright posture, scoliosis, and the ability to maintain prolonged sitting and writing were seen.

The Intensive Phase

Then Louis was advised to take intensive remedial classes in special classes for children with dyslexia. Classes are held 5 days a week, for 4 hours each. Evaluation is performed every month. In each evaluation all teachers and parents were present. The series of evaluation activities consisted of exposure to behaviour, children's responses in adapting, and children's ability to count, literacy, and play in groups.

The Intensive phase ran for 18 months. We will explain the intensive phase in 4 phases. The first is the initial phase with the main behavioural problem. The second phase is the adjustment phase with changes in the response and improvement of social performance but accompanied by new behaviour as an impulsive response. The third is a phase of

ups and downs but not as great as phases 1 and 2. The fourth is in the phase of maintaining achievements.

Intensive remedial teaching is a structured and systematic curriculum designed for Louis, to decrease reluctance in reading, and increase engagement and motivation in reading and writing, the teacher in remedial teaching made personalized worksheets based on assessment results.

Strategies to improve behaviour:

1. Allowed a discussion on how to introduce yourself (staring at the other person, head straight, loud voice)
2. Make it a habit to introduce yourself when meeting new friends
3. Reinforcement is given with instant appraisal
4. Verbal and physical reminders constantly
5. Gives an example of the expected intonation, and replies with a smile
6. Louis was encouraged to do tasks independently, especially the task which had already been repeated.
7. Give Louis the opportunity to try higher difficulty tasks
8. Habit of asking for help sufficiently
9. Louis is given relatively easy questions, and he can work on them. Continue by slightly increasing the difficulty of the questions according to the needs
10. Make an agreement with the child to immediately do the task and no hesitation
11. Pay attention to the speed of completion of work, reminders along the task perform
12. Time-based assignments
13. Quality of work completion is supervised by giving more attention to the difficult question
14. Giving time to perform self-correction
15. Reminded to do the easy questions first
16. Learn flexibility when doing assignments
17. Items/equipment that are only needed are on the table
18. Maintaining focus even though there are lots of distractions (objects, environment, sounds)

Learning strategies to improve reading and comprehension

1. Adjustment of a reading worksheet, decrease font size and spacing gradually
2. Reading level start from below Louis's capability (grade 2)
3. Read aloud with attention to accuracy, punctuation, and speed

4. In practicing punctuation, the teacher made a highlighter with a colorful pen, so Louis recognizes the punctuation.
5. Read with respect to reading intonation
6. Listening to how to read with the correct intonation
7. Repeating the reading exemplified by the teacher
8. Read simple text stories
9. Mark words that are not understood
10. Look up the meaning of words that are not understood in the dictionary
11. Allow Louis to make a note of explanations about new vocabulary
12. Picture card with sentences
13. Stories with a sequential picture to help understand story sequences
14. Practice making suggestions, responses, and conclusions from an article

Learning strategies to improve writing

1. An explanation of conjunctions is given
2. Explanation of each connecting word with concrete examples in the surrounding environment
3. Arrange words into simple sentences
4. Worksheet adjustment using a large grid book and customized worksheet
5. Practice writing specific letters which are disproportionate
6. Reminder to make proportional spacing: not too wide or too narrow

Learning strategies to improve math

1. Using learning media in understanding multiplication and division. Multiplication is explained by the concept of repeated addition
2. Follow sequential directions
3. Teaches recognize patterns
4. Explain the steps on how to do tiered division
5. Explain estimation by forming a reasonable guess about the amount, magnitude, and size.
6. More practice on visualizes and mental pictures of numbers while counting
7. Practice spatial orientation and compass direction

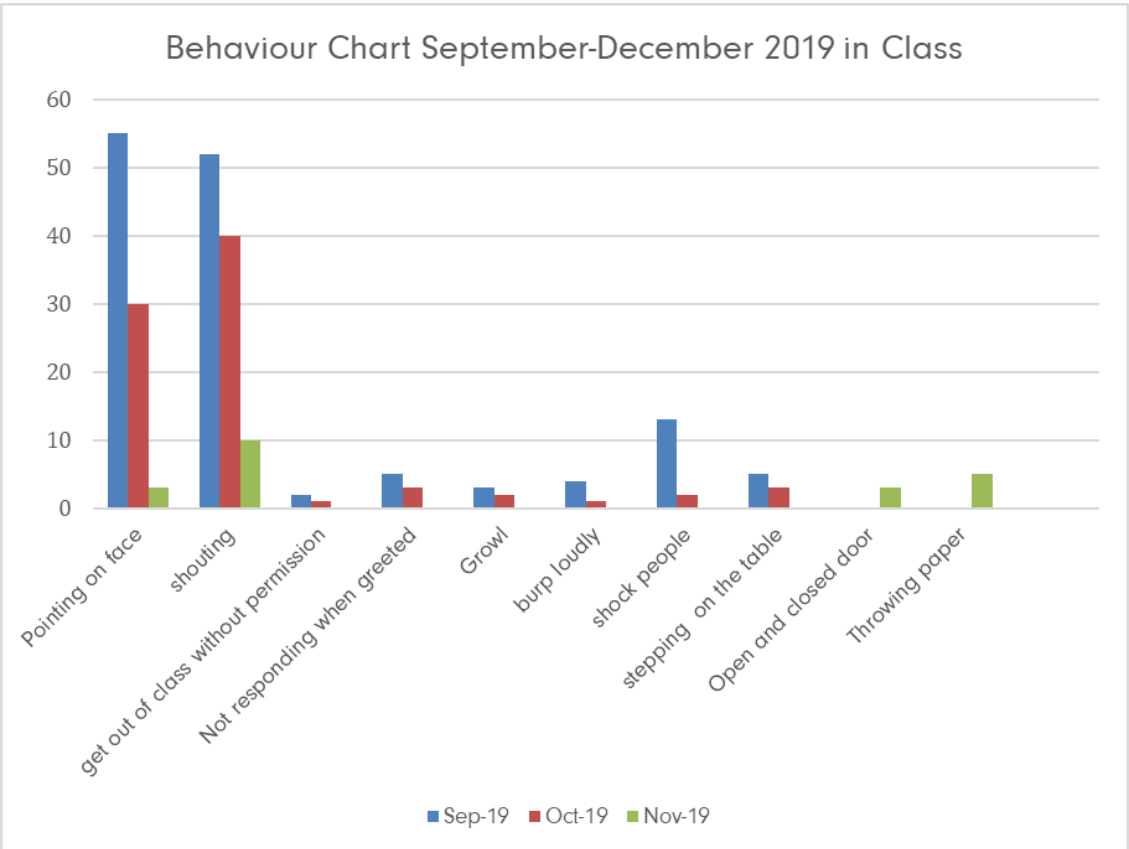
The most important thing is to give opportunity, proper reward, or reinforcement. The teachers also increased the difficulty step by step to get comprehension and retention of learning. Remedial teaching is carried out in a structured and systematic manner in order to achieve the overlearning stage and in the end, is automation.

Other than academic performance, Louis has a program in physical therapy due to his condition of dyspraxia. Learning strategies to improve posture and motoric performance are performed in physical therapy sessions including stretching exercises for flexibility,

endurance exercise, abdominal muscle strengthening exercise, and active exercise for posture correction.

During physical activity, Louis is constantly given feedback on how to perform in the right position, using verbal reminders, video and photos, and a mirror. These programs are evaluated every month during intensive remedial teaching and every three months after intensive remedial teaching is finished.

The following is detailed behaviour shown by Louis during the September-December 2019 period.



Timeline of Behaviour

During three months of detailed observations and frequency charts, Louis seems to have difficulty controlling himself to respond appropriately. Louis shows this attitude in uncomfortable, unpleasant situations or situations where he must respond verbally, but Louis has difficulty responding verbally. While reducing unwanted behaviour, what the teacher in the intensive remedial class does is provide verbal reminders, giving

January-April 2019	May-August 2019	September-December 2019	January-March ' 2020	April-June 2020
CHALLENGING BEHAVIOUR				
♦ Behavioural issues dominate. ♦ Make fun of friends ♦ Growling in response when asked ♦ Shout if he doesn't want to answer ♦ high intonation ♦ put up a middle finger ♦ shout if he doesn't like the food that is brought ♦ There is a desire to interact with friends, shown unnaturally: giving a chair to a friend in need. ♦ It's still hard to separate from mother when class is about to start sticking with mother, standing behind mother, being ushered into class	Social Skills and Social Norms adaptation was very difficult. Often misperceptions. Shaved his eyebrows because he thought others were paying attention to his eyebrows (he doesn't like being noticed or looked at directly by friends) thinks other children are cheating in the game, when in fact Louis is younger and doesn't understand the rules. Start following conversations with friends. Begin to be trained to lower the intonation of high voices.	Improvement in social skills. Ready to chat with friends (speaking intonation is still high) Already want to take part in sitting in a circle with other children.	Behaviour has begun to be easy to follow directions. Can follow the rules of the activity, participating in activities at the market: Following a friend who acts as group leader, does not understand standing in a queue, and does not want to ask the seller at the market.	Start online learning. Very shy in front of camera. Closed the camera, only showing eyebrows, wearing a hat while studying online.

January-April 2019	May-August 2019	September-December 2019	January-March 2020	April-June 2020
LEARNING ATTITUDE				
♦ Often sleepy ♦ Going in and out of class without permission ♦ Unwilling to be corrected, a learning attitude is shown by growling, shouting ♦ Need a reminder to stay seated doing assignments, can't be left by the teacher	♦ Rarely sleepy ♦ He was willing to be corrected by reducing shouting and growling.	Never sleepy in class Ready to be corrected for homework. Poking if he wants to ask a question.	Getting easier to correct if there is a wrong answer Math: does not want to re-calculate even though there is still time Does not always ask questions, even though found difficult.	Tends to be silent in online settings, does not want to be corrected, and answers short questions.
ACADEMIC ACHIEVEMENT				
Should have been in 5th grade, but his ability is at the level of 3rd grade. ♦ Reading comprehension ♦ Answering simple questions on the text ♦ when reading: punctuation not noticed. ♦ Difficulty in cutting with scissors, and folding papers.	Has entered the 4th-grade material: least common multiple & the greatest common divisor, identify moral value from stories.	Already want to try a presentation in front of the class. But not yet looking at the audience. Answering questions using descriptive sentences. Willing to follow handicraft activity.	Starts taking the school exam test preparation.	Elementary school final exam test questions, there are still difficulties in math problems that use formulas (such as area, and volume)
TREATMENT				
No pharmacotherapy	Pharmaco-therapy initiated.	Pharmacotherapy continued		Suggestions for taking medication further but discontinued by parents.

consequences for example by apologizing when burping or shouting in other people's faces, and cleaning up the torn pieces of paper that Louis threw away.

After Intensive Remedial

After intensive remedial ended, Louis completed the final elementary school exam. Then parents enroll him in inclusive schools with 5 children per class. Louis entered secondary school. Louis was placed in special classes and has some accommodation for tasks and teaching material. He sometimes joined the regular class (with a total of 20 students) for less literacy-based material, such as sports and art.

Louis remained to follow remedial therapy after school. In the last evaluation of the remedial session, there is still a note of behaviour that needs to be improved, namely reducing the attitude of opposition and behaviour that does not want to listen. In therapy sessions, emphasis is placed on social-emotional skills to increase self-confidence and how to socialize by starting conversations, asking questions, telling experiences), and using appropriate facial expressions.

Remedial Teaching

During the remedial teaching, Louis was taught to use math and literacy for functional activities, such as reading maps and counting discounts from the regular price. Activities in remedial teaching also included retelling the contents of paragraphs, being able to draw the floor plan of his own house, describing the trip according to the plan, and making his daily plans and daily expenses.

Louis was introduced to the terms debit, credit, and balance to make a simple note of his expenses. He also taught me to record financial expenditure and income data with a table in excel format.

Socio-Emotional Therapy

Louis joined an individual and group therapy session of a social-emotional class. The individual sessions lasted from July 2020-September 2022, once a week for 45 minutes. Louis planned to continue with group sessions that consist of four sessions, every week, each session lasting for 3 hours.

During the early individual sessions of the social class, which was held online due to the pandemic COVID-19, the therapist was putting in a great deal of work to get Louis on camera. Louis was presented with activities to improve his expressions, knowing his strengths, ability to use verbal cues, and ability to talk and make eye contact with others. Our team started to design and develop his social skills practically in these group sessions.

Physical Therapy

Physical therapy sessions were developed to correct his posture and the planning of a motoric activity. Physical fitness can be affected by inactivity and less preference or choice of exercise. Louis often complained of getting tired easily and showed poor endurance during exercise. Exercises consisted of strengthening, plank, and stretching of the lower extremity. Louis performed the exercise with monitoring and extra support, verbal reminders from his therapist, and repetition of instructions.

Follow-up and Outcomes

Louis is now entering grade 9th. He has some difficulties in building friendships, feeling as if he has no friends. He entered an inclusive school. His academic level overall is now equal to 9th grade except for science. He eats alone during the break.

He is in a class now with 5 children but still eats alone during breaks. He recently initiated buying a meal in the canteen, but after a long time, he wanted to bring his food and eat it himself. He tried to engage with other students by starting a conversation during mealtimes at the canteen.

His mother reported that Louis joined youth camping for 12 days. For the first two days, he cried and begged for home, but later he followed the activity until he finished. After camping finished, his parents noted that he was more expressive, and smiled more often. Louis also has a 3D drawing course that he enjoyed, and his parents see the result of his design as excellent.

At home, he likes to bake from recipes, learn to use online shopping to order food, and calculate pocket money and he has been given the task of taking care of the family pet.

During the latest interview with Louis, he realized he has difficulty building friendships, and he is willing to engage in activities that are provided by the Association to increase this skill. During the first group session, Louis was initiated to present in front of other participants. He answered questions with short sentences. He also tried to have eye contact with other participants. However, the vocal tone is not appropriate, with minimal effect and a very limited smile.

DISCUSSIONS

Early Identification

Louis has been going through some interventions toward better performance in social and emotional behaviour and academic achievement. Parents have usually seen the development of children with problems since preschool age, but these findings are not

always followed up with the right intervention. So Louis was still experiencing the difficulties he faced every day at preschool and the more severe challenges found in terms of language in elementary school. Repeated failures and difficulties encountered, without any appropriate accommodations had an impact on Louis' behaviour when he was diagnosed at the age of close to 10 years.

Early detection of dyslexia can start from the age of under 3 years. The most frequent complaints were speech delays and non-silent behaviour. Louis has a speech delay in his development. Early identification can also be done when children start school activities. The ability to self-regulate when temporarily separated from parents can be observed from preschool age. Louis has been found to have these symptoms. However, this matter has not been carried out in a structured manner and has not corrected his attitudes to conform to the social norm.

A dyslexic individual can have more than one comorbid condition and rarely even stand alone. Dyslexia conditions along with dyscalculia and overlapped attention deficit are very common, making reading numbers a real challenge. Dyslexia and dyscalculia also affect how children comprehend word problems, use formulas, and perform calculations using the right mathematical order. They also do not have visual images in their mind about clusters of numbers or arithmetical strategies. Those conditions make them use immature problem-solving and inefficient strategies to solve problems (Hayes, 2018).

Language development and behaviour are closely related. Behavioural problems are seen in executive function disorders. Executive function is a mental process that individuals have for self-control, working memory, and cognitive flexibility. Children with language disorders also have executive function problems, namely working memory. Good language skills require thought processes, memory work, and execution of the speech muscles. (Alia, Munadia, & Aufi, 2021)

In observing children with language development delayed, some indicators of language immaturity in dyslexia at risk are seen. The child does understand what is being said, but cannot articulate a suitable response. The child speaks in single words or disjointed sentences and struggles to learn new words. He relies on routines to understand what is being said and gets very upset when routines are changed. These sorts of communication difficulties can be very frustrating for a child with dyslexia, and this, in turn, can cause problems with behaviour, and impact overall learning and therefore his academic potential (Hayes, 2018).

The Up and Down: Behavioural Management

Behaviour that appears to be very difficult to manage is a form of impulsivity. Impulsivity is one of the predominant forms of ADHD. The ability to self-regulate is also part of the

executive functions. The behavioural journey found in Louis started from a young age, since the age of 3, parents have found that children have difficulty participating in joint activities at school. Since entering elementary school age, language difficulties are becoming more evident and parents find their children unable to follow lessons at school, especially in the language area.

Louis has a combination of symptoms and signs of ADHD, with a predominance of impulsivity. In the learning process, it is not only hyperactivity that becomes a learning barrier in ADHD. However, dominating inattention and impulsivity also interfere with the learning process. In DSM V hyperactivity and impulsivity are explained as 'often leaves seat in situations when remaining seated is expected, often unable to play or engage in leisure activities quietly, often interrupt or intrudes on others. (Association, 2013). Because there is a problem of impulsivity, Louis also has difficulty responding to signs of social language appropriately, so the behaviour that appears is behaviour that shows anger.

The impulsive behaviour shown by Louis occurs during the learning process, where it takes a readiness to learn, sit, listen, follow directions, understand new concepts, and ask questions. This learning readiness is shown in a good executive function. (Semenov & Zelazo, 2018).

The explanation for this fluctuating behaviour is due to several factors. The first is the condition of severe dyslexia (including social (pragmatic) communication disorder), the age at which dyslexia was first diagnosed, and inadequate intervention.

The delay in diagnosis is due to not many professions in Indonesia that can distinguish dyslexia from other conditions. So that delays in diagnosis can occur. Whereas dyslexia that is not managed until the age of 8 years can be left behind and will be difficult to catch up. Louis himself was diagnosed at the age of 9 years and 11 months.

If a determined assessor draws on enough cognitive measures, it is relatively easy to find strengths, weaknesses, and discrepancies and subsequently build a richer diagnosis. And for receiving institutions, there are also some challenges. The clinical judgment and processes behind what has been seen as behaviour and social-emotional problems in Louis are also not easy to translate into proper accommodations. It is hardly surprising, therefore, that a high level of heterogeneity exists in assessor practices, with significant inconsistency and reliability in the way that dyslexia is diagnosed. (Elliot, 2020)

Postponing diagnosis, and then basing a determination on the individual's response to educational intervention, poses a significant existential threat to a vast, growing, and often problematic dyslexia assessment (Elliot, 2020). It becomes more complex because it is not dyslexia that is late to treat but also ADHD. Evidence-based treatment for ADHD is initiated with behavioural parenting training, behavioural intervention, and medication.

Delaying evidence-based therapy is a future problem for mental health. (Jones & Rabinovitch, 2014)

Interventions for dyslexia before entering school prepare the child to be ready for school. School activities are complex, dynamic, and sometimes full of challenges, but should be fun. Aspects covered in school readiness include the child's health condition, evaluation of independence abilities, evaluation of psychological maturity, and evaluation of academic performance. (PMR Specialist Approach to Children's School Readiness, 2020)

The disturbances in behaviour due to the opposite disorder are associated with distress in the individual or his social context and impact negatively on social, educational, occupational, or other important areas of functioning. Behavioural issues related to language problems as the core of dyslexia are affected greatly in the matter of the development of cognitive functions, including perception, attention, and short-term memory. Delayed language development may hinder the development of sustained attention and can lead to poorer and more slowly developing receptive and expressive language disorders. The association between language and attention is very related to vocabulary development. (Maniadaki & Kakourus, 2018)

Parents Involvement

Parents' involvement is important in the overall cognitive development of a child. A child with genetically challenging behaviour is not easily managed. Therefore, parenting behavioural training should begin as early as possible. Parental behaviour training is proven as one of the core methods to manage behaviour in preschool hyperactivity and inattentive children. Hyperactive preschoolers need guidance on how to behave, how to control reactions, and flexibility in emotional response. While children in inattentive predominant should be given constant reminders, structured instructions, an activity that increase their awareness, and sometimes should involve all of their sensory modalities. Even in inattentive children, impulsivity can also be found. Emotional regulation is one of the cognitive flexibility contexts of executive functions sometimes become challenging in managing behaviour. That difficulty should be acknowledged by parents. Moreover, parents with the same problem during childhood, if they grow up with a lack of compassion, would perform the same way parenting to their child. That is why one of the biggest challenges is to make parents realize their condition and that their children are genetically inherited. Parents with ADHD and emotional disturbances also need to take treatment. Therefore, the first thing in parental involvement is full consideration and full awareness of parents about their condition.

Louis's parents had attended seminars and workshops about dyslexia held by the Dyslexia Association of Indonesia. They are also actively involved in community activity that gathers dyslexic children and families to support each other. Louis is encouraged to

join some clubs in the community such as the chess club, and Catholic Youth Club, and frequently meet up with peers and cousins.

From clinical experience, dyslexic children with severe social language disorders are usually accompanied by parents who also might have social language disorders. In clinical practice, in the observations during the assessment, parents of children with dyslexia and severe social language disorders, also have limitations in oral expression, rarely ask questions during consultations or evaluations, look stiff or less flexible, and have minimal facial expressions. Other parents with social language problems and adult ADHD look very anxious, often interrupt during explanations, or expect quick results.

Parental involvement is also key in drug administration. Louis's parents had a hard time getting Louis to take medicine for various reasons, and the parents did not adequately correct Louis's drug-hiding behaviour. During the program, Louis's parents followed each evaluation, listening to directions and input. However, in the evaluations, most of the parents did not do what was directed e.g., ask Louis to be responsible for the pets (toileting, feeding). This simple task is even carried out by a household assistant. Louis was also asked to do regular physical activities every day such as morning walks, walking the dog, and riding a bicycle. This directive was not carried out because Louis did not want it to.

During periodic evaluations, parents need to be given briefings to understand what is happening to their children, know strategies that need to be done at home, and monitor programs that are carried out at home. This all requires effort, creativity, struggle, and high tenacity from parents. Adults with ADHD and anxiety often have planning disorders or executive dysfunction. so that they also have difficulty starting to prioritize which one comes first for the child. This is where the role of parents (as individuals who monitor dyslexic children at home) needs to receive guidance, counseling, and periodic evaluation of their emotional status. Therefore, other professionals are also needed, such as psychologists, psychiatrists, and support groups.

Parents are a key role. Parents can be given homework as a helpline for both parents and students. Parents can also be a connector between professional and school institutions. Effective communication with the school can provide parents with considerable support. (Reid, 2011). Schools are expected to have sufficient knowledge of children's conditions and provide adequate resources to manage children's special learning needs. Parents are also expected to give feedback to teachers about their child’s learning profiles.

Communication between parents and school is important as it can help to clear up any misunderstanding and help both parents and school to work collaboratively and positively. (Reid, A complete guide for parents and those who help them, 2011). Parental involvement from early childhood, especially for ADHD children with language and social

skill problems should be helped by lesser verbal instructions. Teachers and parents should adopt a more directive and less interactional demanding and supportive verbal style of communication. (Maniadaki & Kakourus, 2018)

Social Competency Develop within Remedial Teaching

Social competency is one of the challenging skills to achieve. Entering a new social life (new school, new sports clubs, new dance club) for dyslexic learners needs preparations. In this case, we found Louis very hard to start a conversation, express his feeling (dislike or like), or join a fun game during break. These skills are important to enter social life. Likewise in the remedial teaching of dyslexia, social competence also should be taught in structured and systematic constructs. These layers of competency are not always seen as a learning curve for parents, professionals, or educators. It is the same as when we are teaching math.

What makes dyslexics have real difficulties in social languages, such as Louis experienced? The typical human brain is programmed to deal first with its owner's survival and emotional needs. Consequently, the human brain has learned over thousands of years that survival and emotional messages must have high priority when it filters through all the incoming signals from the body's senses. The pathway of emotional signals starts from the thalamus and takes two different routes through the amygdala. The first pathway, called the thalamic pathway, sends the signals directly from the thalamus to the amygdala. The second possibility called the cortical pathway is for the thalamus to direct the signals first to the cerebral cortex (in the cerebrum) for cognitive processing, and then to the amygdala. (Sousa D. A., 2016) The first pathway if it continues to rise then emotional responses become prominent.

However, if the second pathway (amygdala first then cerebral) is built through a series of environmental support and accommodation, the fear or anxiety will be resolvedwith good coping skills. An example of the first path, for example, the child hears the teacher asking children in the class to tell a story about a hobby, and the child is silent and cries. If this pathway is strengthened, because no correction has been made for this kind of behaviour, then it will progress into phobia, anxiety, antisocial, and other mental health issues. Meanwhile, if the second path is activated, the steps chosen by the child are (with the help of others, if the child has not found a way) asking for extra time, to think about his hobby, try self-talk, write it down and step in front of the class. Therefore, psychotherapy alone is rarely successful in treating anxiety and phobias without real-life implementation. (Sousa D. A., 2016)

What steps we made for Louis are divided according to his emotional and behavioural issues. First, we created opportunities to start a conversation. We We do not pursue the conversation always in two ways. Verbal responses and body gesture approval are welcome.

The teacher starts with a topic that is interesting to Louis, which is chess. He was allowed to present how to play chess. And we allowed him to speak on his level current abilities (chosen words, ideas, as much time as he needs) and sometimes we allowed him to have "thinking time". These are the strategies to teach communication skills to a starter like Louis.

A form of social language disorder in dyslexia is often considered a form of introverted character or part of a lack of stimulation. The forms of social language difficulties are listed in the detailed description of social communication disorder in DSM-V. This disorder is in the form of difficulty obeying social rules and conventions of language (ie, greeting by the context and sharing information), impairments in changing communicative style by the situation or needs of the listening party, waiting for conversational turns, reformulating communicative intent in case of misunderstandings, knowing how to use verbal and nonverbal iconic gestures in the context of the speech, and problems in inferring the implied message with metaphors/ironies/ similes/aphorisms. Features supporting diagnosis as per DSM-5 include a delay in acquiring spoken language, along with current/ lifetime structural language disorders. The affected children are also reported to display elevated levels of ADHD, LDs, and behavioural problems. (Topal, Samurcu, Taskiran, Tufan, & Semerci, 2018)

What is even more complicated is dyslexia is not a singular condition. Behaviour issues as part of ADHD altogether complete the complexity. These social skills difficulties negatively impact their social interactions, including forming positive peer relationships. Difficulties in early language development in children with dyslexia and ADHD in turn further minimize opportunities for language skills development. (Maniadaki & Kakourus, 2018) Therefore, early treatment of these problems is of paramount importance. Early treatment to reduce the severity of dyslexia will decrease the possibility of arising comorbidity in a later stage.

How can we build social competency? Social competency is the ability to handle social communication effectively. (Orpinas, 2010) Building competence in any form requires a strong base. Competence is built in stages like stairs or pyramids. However, there is no peak in social competence. Start social skills, it takes stages. This competence can be built from the smallest environment, namely the home, by starting communication with children. If the child has entered a group activity, such as a sports group, home environment group, or group with the same interest, teach the child to start a conversation. To choose what activities to participate in, choose relatively simple activities, go to a basic class first, or a class with a small number of participants. To help children overcome social anxiety, regularly observe child's interaction with other children, observe, and positively give feedback. (Franklin, 2018)

Therefore, we need a formal emotion-curriculum based. The program should be designed to provide a forum for open, non-judgmental discussion of social-emotional issues and to

teach specific social-emotional skills. Topics common to all grade levels include listening, cooperating, understanding other feelings, expressing feelings appropriately, responding to difficult behaviour, and problem-solving. (Stein, 2010)

In remedial intensive intervention for Louis, teachers use multisensory methods and creative and different ways of delivering concepts to make Louis understood. It is not an easy task to teach children with behaviour challenges like Louis. However, over time, using strategies that are structured and systematically given, instant feedback and appraisal needs are given, and the behaviour became calmer and easier to control. It is not enough to only use multisensory methods and give each dyslexic student the same task and material. Teachers in remedial classes also define the strengthened point of Louis. Louis is actually a holistic thinker; he can find a problem solver for some math problems after practicing the material. Therefore, it is also important to have objective observations. (Stacey & Fowler, 2020)

Remedial teaching described in various strategies could assist learning in many different ways. Techniques to assist learning in remedial include mental and visual mind exercises to manipulate information given. Chunking information into smaller parts helps working memory work efficiently. (Stacey & Fowler, 2020) A recall is also provided with taking notes, preferably with handwriting. All the information is collected and consolidated in certain ways needed. Using mind mapping to review all the information along with verbal self-talk. Finally, metacognition is practiced in highly demanding reading comprehension. (Scheff, Hudson, Tarsha, & Cutting, 2018)

Transitional Stages to Higher Education

Transition to the next school. Can dyslexia and its various co-morbidities give Louis the opportunity to attend university? Or the choices are limited, considering the complexity of assignments, lectures, and group learning that will be faced at the university level. We should not rule out anything that could happen. The most important thing is to provide readiness for Louis wherever he goes to school, it needs to be ensured according to his choice. Learning problems will always be there. What needs to be prepared, of course, are basic understanding skills in public places. For example, using public transportation, viewing class schedules, collecting assignments according to deadlines, and exam schedules. All these activities are summarized in the executive functions exercise. Therefore, executive functions must be an important part of the school readiness assessment which is continuously trained, corrected, and increased levels of difficulty in a child's daily life.

Entering college will make children face much bigger challenges. The increasingly tiered complexity and fast dynamics require an ability not only good executive function. But moreover, it requires metacognitive awareness. Metacognitive awareness refers to students' self-understanding of their learning profile, as well as their strength and

weaknesses in academic and social situations, influencing their selections of specific strategies for academic tasks. These processes should be reflected in executive function processes for example reading comprehension, written language, homework, and studying for exams. (Meltzer, 2018)

CONCLUSIONS

Labelling or diagnosing child development problems is important for professionals in the field of child development. Delay in establishing a diagnosis result in delays in intervention. Brain development takes a long time to accept something new, especially to change behaviour. Attitude correction, challenging behaviour correction, and unexpected behaviours must be carried out by all parties in a structured manner. Reading problems in dyslexia must also go hand in hand with improving social language skills.

Managing social emotions requires practice, learning, and settings that require children to adjust socially. Social competence is formed with a special strategy that is continuous so that the attitudes, thought patterns and actions shown by the child are as expected social norms.

Providing explicit instruction for specific emotional regulation skills is important throughout all activities. As we know with dyslexia, learners have difficulty in working memory and slow processing speed. Schools and other higher-graded institutions also must provide appropriate academic support to decrease emotional triggers.

In the future, it is hoped that more parties will be open to deepening dyslexia and looking at dyslexia comprehensively. Organizations working in the field of dyslexia are also expected to develop terminology that includes conditions other than reading difficulties. The agreement and the common vision of all parties are expected to provide more understanding for professionals and to join hands to prevent failure in dyslexic children.

REFERENCES

Alia, D., Munadia, & Aufi, A. (2021). *Language Disorders in Children-Relationship with Future Quality of Life.* Banda Aceh: Syiah Kuala University Press.

Association, A. P. (2013). *Desk Reference to the Diagnostic Criteria from DSM-5*. Arlington: American Psychiatric Publishing.

Elliot, J. G. (2020). It's Time to Be Scientific About Dyslexia. *Reading Research Quarterly*, pp. S61-S75.

Franklin, D. (2018). *Helping your child with language-based learning disabilities*. Oakland: Raincoast Books.

Hayes, C. (2018). Developmental Dyslexia from Birth to Eight. New York: Routledge.

Jones, H. A., & Rabinovitch, A. E. (2014). Evidence -BAsed Treament of Attention-Deficit/ Hyperactivity Disorder in Children and Adolescent. In C. A. Alfano, & D. C. Beidel (Eds.), *Comprehensive Evidence-Based Interventions for Children and Adolescent* (pp. 177-189). Hoboken, New Jersey: John Wiley & Sons.

Maniadaki, K., & Kakourus, E. (2018). *The Complete Guide to ADHD Nature, Diagnosis, and Treatment.* New York: Routledge.

Meltzer, L. (2018). Creating Strategic Classroom and School Emmbedding Executive Function Strategies in Curriculum. In L. Meltzer, *Executive Functionin Education from Theory to Practice* (pp. 263-299). New York : Guilford Publications.

Orpinas, P. (2010). Social Competence. In I. B. Weiner, & W. E. Craighead (Eds.), *The Corsini Encyclopedia of Psychology* (pp. 1623-1625). New York: John Wiley & Sons.

Reid, G. (2011). *A complete guide for parents and those who help them*. West Sussex: John Wiley & Sons.

Reid, G. (2012). *Dyslexia* 3rd Ed. London: Bloomsbury Publishing.

Reid, G. (2017). *Dyslexia in early years*. London: Jessica Kingsley.

Saltz, G. (2017). *The Power of Different*. New York: Flatiron Books.

Scheff, J. D., Hudson, N. M., Tarsha, M., & Cutting, L. E. (2018). Executive Function and Reading Difficulties. In L. Meltzer, *Executive Function in Education from Theory to Practice* (pp. 201-17). New York: Guilford Publications.

Semenov, A. D., & Zelazo, P. D. (2018). The development of hot and cool executive function, a foundation for learning in the preschool years. In L. Meltzer, *Executive Function in Education* (pp. 86-93). New York: Guilford Press.

Solek, P., & Soegondo, K. D. (2018). *Dyslexia Today Genius Tomorrow* (2 ed.). Bandung: Dyslexia Association of Indonesia.

Sousa, D. A. (2016). How the special needs brain learns, 3rd ed. London: SAGE Publications.

Specialist, I. A. (2020). PMR Specialist Approach to Children's School Readiness. In M. S. Prananta, Munadia, & R. N. Hartanto, *School Readiness, Assessment Guide and Recommendations for Physical Medicine and Rehabilitation* (pp. 29-37). Jakarta: Indonesia Association of Physical Medicine and Rehabilitation Specialist.

Stacey, G., & Fowler, S. (2020). *Development of Dyslexia and other SpLDs*. New York: Routledge.

Stein, J. A. (2010). Emotional self-regulation: A critical component of executive function. In L. Meltzer, *Promoting Executive Function in the classroom* (pp. 175-188). New York: Gilford Press.

Topal, Z., Samurcu, N. D., Taskiran, S., Tufan, A. E., & Semerci, B. (2018). Social communication disorder: a narrative review on current insights. *Neuropsychiatric Disease and Treatment*, 2039–2046.

Asia Pacific Journal of Developmental Differences

Guidelines for Contributors

Overview

The Asia Pacific Journal of Developmental Differences (APJDD) will be unique in addressing a range of special educational needs including dyslexia, autism, dyspraxia, dyscalculia, ADHD in the Asian context. The journal will cover theory into practice and will provide a showcase for research in the Asian context as well as highlighting research areas which have implications for further research within Asia and beyond.

Frequency of Journal

The Journal will be published twice a year in January and July.

Contributions Considered for the Journal

Primary consideration for publications will be given to manuscripts that are focused on developmental differences within the Asia Pacific region. Manuscripts will be peer reviewed and included in the journal on the following criteria:

- They contribute to the further understanding of developmental differences as well as the applications and implications in the educational, social and cultural environments.
- They include sound research methods, interpretation and validity of results
- They contain organised and clarity of writing
- They contribute to the local Asian context
- They should be original papers that have not been submitted to other journals or publications.

Editorial Policy—Retractions

The APJDD takes the issue of retractions very seriously. In line with requirements of major academic journals the APJDD will continue to monitor publications for retractions. No future citation will be permitted for articles that have been retracted and a correction will be issued if any such article is published in error. In the case of citations prior to retraction no such correction will be issued, in line with the policy for other journals of this type. Please contact the editor in the first instance if there are any concerns. COPE guidelines have been accessed in preparing this guidance.

Articles published in the APJDD should be original work that has not been published in this form elsewhere. In rare instances where previous publication has been made, this will be fully acknowledged.

Scientific Review Committee

In common with a number of other academic journals, a scientific review committee assists the editor and editorial board in the review process.

Submission of Manuscripts

All manuscripts are to be sent in electronic copy (MS WORD) as well as a PDF copy of the final edited document. PDF copy is required to verify the word copy and for publishing purposes. There is no need to submit hard copies of manuscripts.

Images, charts and diagrams should be sent separately where possible to ensure high quality reproductions.

Submissions are to be emailed to the editor at both email addresses below:

Angela Fawcett
DAS Research Consultant
Dyslexia Association of Singapore,
Emeritus Professor, Swansea University,
angela@das.org.sg

Deborah Hewes
Managing Editor
Dyslexia Association of Singapore
www.das.org.sg/publications/49-research-journal.html
deborah.hewes@das.org.sg

DAS Research Committee
Dyslexia Association of Singapore
www.das.org.sg/about-dyslexia/research/current-research.html
research@das.org.sg

Preparation of Manuscripts

It is expected that all manuscripts be submitted using the American Psychological Association (APA) standard of referencing and publication. APA style is detailed in the Publication Manual of the American Psychological Association (7th ed), which offers sound guidance for writing with clarity, conciseness and simplicity. Authors should follow the APA style in preparation of their manuscripts.

DYSLEXIA ASSOCIATION DAS OF SINGAPORE

Our Mission: Helping People with Dyslexia and Specific Learning Differences Achieve

Our Goal: To build a world class organisation dedicated to helping people with dyslexia and those with specific learning differences in Singapore.

Our Aims:

- To put quality first in delivering a comprehensive and effective professional service for dyslexic people and those with specific learning differences on a not-for profit basis.
- To provide an assessment service for individuals at risk of having dyslexia and/or specific learning differences.
- To provide educational programmes and other support services for individuals with dyslexia and/or specific learning differences.
- To raise public and professional awareness of the nature and incidence of dyslexia and specific learning differences.
- To enable others (teachers, parents and professionals) to help dyslexic individuals and those with specific learning differences.
- To assist and elicit financial and other support for people with dyslexia, those with specific learning differences and their families.
- To promote and carry out local research into dyslexia, specific learning differences and to disseminate results.
- To network with other organisations in Singapore and internationally to bring best practices to the DAS and Singapore.

DAS as a Social Enterprise

- We provide high-quality, professional, innovative and client-focused solutions to create and sustain services for the dyslexic community in Singapore and the region.

- We operate as a financially viable and cost-effective business which at the same time ensures that no dyslexic person is unable to access our services because they cannot afford it.

- We generate social returns on our investments through the development of a dynamic, motivated team of highly qualified and experienced professionals.

- We have a heightened sense of accountability to stakeholders through our professional management team.

Registered in 1991, the Dyslexia Association of Singapore (DAS) is today a vibrant voluntary welfare organisation with over 250 full-time staff who provide a wide array of services for dyslexics not only in Singapore but in the region. DAS Specialist Psychologists conduct assessment and diagnosis for preschool students to adults. DAS Educational Therapists, Speech and Language Therapists and Specialist Teachers provide support for over 3,500 preschool, primary and secondary school students in 14 venues all over Singapore. Increasingly, DAS provides support for dyslexics who also suffer from other Specific Learning Differences such as ADHD, Dyspraxia, Dyscalculia and Non-verbal Learning Differences.

The DAS Academy is a Private Education Institution (PEI) registered with the Council for Private Education (CPE). It is a wholly-owned subsidiary of the Dyslexia Association of Singapore (DAS).

Like DAS, the Academy is also a registered charity with the Commissioner of Charities. DAS Academy delivers a wide range of workshops and courses including a Master of Arts in Special Educational Needs. DAS Academy provides the bridge that links professionals, caregivers and people with special needs.

Asia Pacific Journal of Developmental Differences

Volume 10 ♦ Number 1 ♦ January 2023

Contents

DYSLEXIA ASSOCIATION DAS OF SINGAPORE

www.das.org.sg