



## The Teaching of Maths to Students with Dyslexia: A Teachers' Perspective

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### Abstract

*This case study explores the perceptions of teachers who teach maths to students with dyslexia at the Dyslexia Association of Singapore (DAS). The authors examined the challenges participants faced when teaching students with dyslexia maths, the processes that were used to help their learners understand maths concepts, and supports that were provided to minimise student anxiety and boost self-esteem. Four distinct challenges emerged including inadequate training, content area language barriers, cognitive style implications and their impact on maths learning, and addressing and remediating students' anxiety towards learning maths and the impact on their self-esteem. Results indicated that teachers enjoy teaching maths to students with dyslexia but find that adequate training, teaching experience, and exposure to multiple teaching strategies are required for success.*

*As DAS is a unique organisation that helps students with dyslexia improve their literacy and numeracy skills, teacher professional development and teacher training are important aspects that need to be in place so that teachers are well-supported and guided to coach these students. Suggestions to meet these challenges are provided.*

**Keywords:** maths, dyslexia, maths anxiety, self-esteem, teacher perception

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Mathematics is a human endeavour, a discipline and an interdisciplinary language and tool (Horn, 2013). From this overarching perspective, we can begin to appreciate the link between maths difficulties and dyslexia. Specifically, that maths difficulties are neither the result of a poor or weak understanding of numeracy concepts, nor due to a lack of number sense. Dyslexia is a specific learning disability that affects the language system and, in particular, phonological processing (Shaywitz & Shaywitz, 2005). These processing deficits can inhibit an individual's ability to learn maths concepts.

To be successful in maths and understand the multitude of maths concepts, an individual must be able to decode the language of maths and understand maths terminology, vocabulary, and word problems. In an effort to find a link between maths difficulties and dyslexia, Malmer (2000) found evidence of weaknesses in the core skills of reading, writing and arithmetic. These core skills influence and affect an individual's cognition, motivation, and behaviour in various situations. Students who are proficient in their core skills have less difficulty understanding concepts and putting in place strategies to reinforce learning. Hence, maths learning not only requires students to have a sense of numeracy, but also the ability to read and understand language in order to comprehend maths instructions and solve maths problems.

Students with linguistic competence skills have the best chance of learning due to the reception and expression of language. According to Malmer (2000), these skills, and a more robust

vocabulary, allow them to develop learning strategies, search for knowledge, and structure their work in ways that allow concepts to be linked in their learning. Therefore, in order for students with dyslexia to have a positive experience learning math, they have to overcome the language barrier that is often associated with the condition (Chen & Li, 2008). For example, in order to understand a maths question, an individual must have basic understanding of language and be able to comprehend the specific components of the prescribed maths skill. Thus, language used to define and express maths concepts and ideas plays a key role in maths teaching and learning.

Researchers suggest that language proficiency and/or competency is one of the crucial factors influencing and impacting students' maths performance (Bernarodo & Calleja, 2005; Clarkson, 2007). Therefore, the ability to learn language should be taken into account when teaching maths to students with a learning disability (LD) such as dyslexia.

The Dyslexia Association of Singapore (DAS) provides specialised training for students with dyslexia (Yeo et al., 2015). DAS teaches more than 2800 students in 13 learning centres throughout the country. In Singapore, maths is particularly important as maths success determines whether a student is promoted to a secondary level or has to retain at the primary level for an additional year of schooling. Six years ago, DAS decided to offer a teaching programme specifically catered to students who experienced difficulties with math. This case study explores the perceptions of teachers who teach maths within this DAS programme.

## Dyslexia

According to Lyon et al., (2003), dyslexia is a specific learning difficulty that is neurobiological in origin. It is characterised by difficulties with accurate and/or fluent word recognition along with poor spelling and decoding abilities. Students diagnosed with dyslexia typically display phonological processing deficits that affect their reading, spelling and writing abilities. Although maths is a subject that involves numbers and symbols, students are required to read and understand maths instructions and word problems in order to perform maths tasks. In this respect, students with dyslexia face great difficulties due to their weak ability to decode and read.

Shaywitz and Shaywitz (2005) detailed two main processes involved in reading and decoding comprehension. Specifically, when decoding words, two interacting processes are involved: word recognition or identification and phonetic analysis. The skill of decoding, as a lower order linguistic function and the basis for reading, means that students are able to segment words into their underlying phonological elements and then link the letters to their corresponding sounds. If a student faces difficulty in decoding, he or she may not be able to recognize or identify words.

Difficulty in decoding can also result in a lack of higher order processes such as comprehension and the ability to draw meaning from text. As so much effort is used in decoding words, the possibility of comprehending the actual text is substantially reduced or compromised.

Hence, students who are affected in this respect are not able to use their higher order linguistic skills to access meaning to what they have read until the printed words have been decoded and identified. Therefore, the difficulty with decoding does not indicate the student's inability to undertake academic tasks, but does show that the students need support and guidance in reading in order for them to accomplish those tasks.

Additionally, students with dyslexia may also display difficulties in areas such as auditory processing, visual processing, organisational skills and attention deficit that can impact maths learning. While these factors are not true of all students with dyslexia, the difficulties may co-exist in certain students and impede their ability to complete maths problems despite strong numerical and computational skills. Chia (2009b) identified the factors contributing to the difficulties faced by students with dyslexia as detailed in Table 1. (overleaf)

## Maths Difficulties and the Language of Math

Typically, maths difficulties manifest as:

- (a) difficulty processing numbers and arithmetic symbols,
- (b) difficulty establishing arithmetic facts, and
- (c) difficulty following arithmetic procedures,

(Chia, 2009a; Macaruso, Harley, & McCloskey, 1992; Temple, 1992).

Table 1. Challenges faced by students with dyslexia.

<b>Auditory processing problems</b>	<b>Visual processing problems</b>	<b>Poor organisational skills</b>
difficulty understanding or recalling what has been taught	difficulty remembering things just or recently seen (e.g. steps shown or models and diagrams used in teaching)	inability to organise materials systematically
difficulty carrying out multi-step directions or instructions correctly (e.g. computing 2 or 3 step word sums)	difficulty copying from the whiteboard (e.g. math symbols and numbers)	poor time management, resulting in incompleteness of tasks
	difficulty performing math word problems as well as specific topics, such as geometry and algebra	tendency to have messy written work and weak spatial skills
		problems with reading comprehension and math (e.g. word problems)

McCloskey and Caramazza (1987) found that maths difficulties may also include:

- (a) difficulty comprehending numerical information as opposed to expressing it,
- (b) difficulty processing numbers written in numerals rather than in words,
- (c) difficulty understanding each digit in written numbers as opposed to the place value of each digit, and
- (d) difficulty handling spoken as opposed to written information.

Malmer (2000) suggests that individuals with dyslexia have difficulty learning maths if:

- (a) the level of abstraction is too advanced and the student is not able to visualise the mathematical computation,
- (b) the demands of rule and procedural memorisation are too great and can tax the individual's working memory, and
- (c) the rate of learning is too fast for the student (i.e., a new concept is introduced and taught before he or

she could understand the previous concept).

Additionally, Butterworth (2003) indicated that students with dyslexia who have maths difficulties have trouble conceptualising, comprehending and manipulating maths problems such as maths questions, materials and concepts. Specifically, Butterworth (2003) found that individuals with dyslexia can have trouble recalling fundamental quantitative concepts, rules, formulae and equations, as well as difficulties in performing maths operations in the correct sequence and solving word problems.

### **Cognitive development**

In learning math, students are required to be able to concentrate, think, and understand symbols and terms used and reason abstractly. Additionally, students must be able to make comparisons on shape, size and quantity. Students must also be able to translate linguistic and numerical information into maths equations. Then, students must choose suitable arithmetic operations to perform calculations or strategies to solve word problems. Finally, the students must be able to generalise these strategies to other situations as well as monitor the problem-solving process in multi-step calculation and word problems (Chia, 2009a). Moreover, Mayer (1987) indicated that maths learning involves the application of different types of knowledge, including,

- (a) linguistic and factual knowledge,
- (b) schema knowledge,
- (c) algorithmic knowledge, and
- (d) strategic knowledge.

Students with weak cognitive development will struggle to achieve mastery in maths if the above skill set is not intact.

Furthermore, to be good at math, students must possess a good maths memory (Keeler & Swanson 2001). Memory is important because it regulates one's ability to recall facts and procedures, especially when performing either a mental calculation or any form of computation. Working memory is a strong predictor of maths achievement and is needed to retain rules, formulae and procedures, as well as to organise information.

Both long and short-term memories are essential for computation and retaining mathematical information. Topics in maths have specific rules in computation and formulae that only pertain to those topics. For instance, there are specific rules in computation and formulae in geometry that are not applicable to algebra. Students must be able to remember and recall specific rules, formulae and procedures when they attempt to solve equations or word problems. However, due to the weak working memory of students with dyslexia, memorisation and recall of specific rules, formulae and procedures may pose a challenge for them.

During assessments, students are often given a limited amount of time to complete mathematical tasks. Time limits do not always allow students to demonstrate their knowledge as their speed of calculation is also being measured. Therefore, when students are slowed down by their reading and computational difficulties, their

performance on the assessment may not match their functional ability (Chia, 2009a). Generally, students with dyslexia require more time than their peers to complete maths tasks, as they may have to decode each word in a maths question. Since these students are not fluent readers, comprehending what has been read can only be achieved after decoding is completed. However, reading which requires a significant amount of decoding may hinder comprehension as the meaning of what is read can be lost on these students, as they struggle to decode each word. In this respect, students with dyslexia may have to read maths questions several times before they can fully understand what is required of them. Malmer (2000) suggested that in view of the complexity of maths learning, students with weak maths skills and/or those who have a LD should be allowed to learn at a slower pace and given extra support if they are to achieve success in math.

Students' thought processes, or their cognitive style in math, can greatly impact their maths learning and problem solving skills (Chinn & Ashcroft, 1998). Riding and Rayner (1998) describe cognitive style as a student's preferred and habitual approach to organising and representing information in any content area. Chinn and Ashcroft (1998) identified two types of cognitive styles in maths learners, specifically, the "inchworm" and the "grasshopper". Inchworms focus on the parts and details of a problem separately, while grasshoppers try to form a holistic overview of the problem and put information together. When solving maths problems, inchworms work in a series of ordered steps, usually forward, but grasshoppers often work backwards from

a trial answer and use multiple methods. After completing the problem, inchworms are unlikely to check and evaluate their answers, while grasshoppers evaluate their answers against original estimates or check by alternate methods. A study undertaken by Chinn et al., (2001) showed that students with dyslexia are more likely to show the characteristics of inchworm compared to students without dyslexia. While both inchworms and grasshoppers are able to solve mathematical problems with accuracy, the results indicated that inchworms exercised less flexibility in their approach and took more time to derive at answers.

### **Linguistic competence**

Maths has its own language, and the language of maths can be as challenging as a foreign language (Freeman & Crawford, 2008; Sterenberg, 2008). As such, language skills have become increasingly important in learning math. One must understand the language used to define maths concepts and express maths ideas in order to demonstrate learning (Chen & Li, 2008; Pierce & Fontaine, 2009). The language of maths is technical and can be very problematic for students, with or without dyslexia, to master. Any struggle with understanding the language of maths can greatly hamper a student's enjoyment and progress in learning maths (Freeman & Crawford, 2008).

According to Munroe & Panchyshyn (1995), technical words in maths often carry specific mathematical definitions that must be taught explicitly to students (e.g. mixed numbers and equivalent fractions). At the same time, there are

also sub-technical words, common words which students already know but have less common definitions in math, which may confuse students if they are unfamiliar. For example, the word "table" means a piece of furniture with four legs and a surface in everyday language, but in maths context, a table means a visual display of information. Pierce and Fontaine (2009) explain that the language of maths involves two main types -the language of words (value, product, coefficient, factor, multiple, area, perimeter, etc.) and the language of symbols ( $\neq$  [not equal to], % [percentage],  $\div$  [divide],  $n$  or  $x$  [variables] etc.). Understanding symbols, the technical language, and the sub-technical language in maths are crucial to maths learning as these allow students to grasp the ideas of each topic as well as engage in maths problem solving.

Students who possess well-developed language skills are able to learn more effectively than those with poor language skills and deficient vocabulary (Malmer, 2000). Learning maths involves calculation and reasoning but, for students with dyslexia who may be able to compute maths calculations accurately and with sound reasoning, the challenges are often with maths vocabulary. In order to read and understand the instructions and details in maths texts, students must decode very concise vocabulary.

Since students with dyslexia struggle with decoding, their ability to comprehend maths text is diminished and their ability to solve problems is severely limited. Often, students with dyslexia are only able to solve problems when the problem to be solved has been expressed in another

form, way or method (Malmer, 2000). For example, rephrasing word problems or using diagrams and manipulatives may assist students in a better understanding of the maths questions.

Similarly, the language of maths can be tricky for students with LD. Students who receive little or no exposure to mathematical thinking, learning, and concepts prior to formal education may find the vocabulary of maths confusing. These students may require more detailed, content specific explanations of maths terms. Moreover, the words used in maths can be confusing, as multiple words often have the same meaning. For example, 'add', 'plus', 'more than', 'and', 'total', 'together/altogether' and 'in all' refer to the concept of addition. Students need to recognise the operations that are associated with specific words. The language barrier associated with maths may cause students with dyslexia to need more time to decode instructions, text in word problems, and to comprehend the text before employing the right steps to derive answers. At times, the act of decoding the text requires so much mental energy that the level of understanding is diminished or becomes defective (Malmer, 2000).

### **Writing difficulties**

In addition to reading difficulties, students with dyslexia may have writing difficulties as similar letters, numbers and symbols are often confused (Malmer, 2000). Students with dyslexia often experience reversals and confuse letters such as 'b' and 'd' or 'b' and 'p', numbers such as '2' and '5' or '6' and '9', as well as symbols such as '<' (smaller than) and '>' (greater

than). When reversals or number confusion occur, students might write '369' instead of '396'. Furthermore, students must be able to accurately carry over values when adding or reducing numbers in addition and subtraction. When completing addition and subtraction equations, students with dyslexia may struggle with directions and confuse their right from their left. This can make maths calculations problematic, as some maths computations have to be calculated from right to left (addition, subtraction and multiplication) while others from left to right (long division). Hence, sequencing and directional difficulties can frustrate students when learning math, impacting their ability to fully understand maths concepts.

Yet another difficulty with mathematics that may affect a student's answers is poor visual-spatial perceptual abilities. For instance, in computing vertical maths sums, a student must align his or her answers in columns to avoid making errors in answers and presentation. Likewise, if the sums involve multi-digit numbers and the decimal point, then placing the decimal point in the wrong place will result in an error (Chia, 2009a).

### **Maths Anxiety and Self-esteem**

In order to acquire maths skills and knowledge, as well as an enjoyment for maths learning, students must develop a positive attitude towards math. The difficulties inherent in learning maths may lead to maths anxiety and decrease self-esteem. Chinn (2008) described maths as a unique subject where usually there is only one correct answer to a question. Hence, students may feel anxious if they

are unable to get the correct answer.

Ashcraft (2000, 2002) defines maths anxiety as a feeling of tension, apprehension, or fear that interferes with maths performance and notes that individuals who are highly anxious in maths have the habit of avoiding math. Typically, the strain and dread in undertaking the maths tasks interferes with performance and ultimately undermines the student's competence in math. Additionally, anxiety may prevent students from taking risks that would otherwise encourage them to explore different methods in problem solving. Chinn (2008) found that students could develop negative attitudes towards learning maths if their anxiety hinders learning and leads to repeated failure. In a 2008 study on a group of students with and without dyslexia, Chinn found that students with dyslexia did not attempt questions they deemed to be difficult in order to avoid failure, and only answered questions that they were confident of solving correctly. Hence, fear of failure can increase feelings of anxiety and lessen the willingness to take risks in learning.

Maths anxiety can also influence the cognitive skills used when completing maths tasks, such as the working memory. The working memory is greatly involved in maths learning. Anxiety may suppress students' ability to activate prior knowledge and exercise their working memory to guide them in solving maths problems. High-stakes testing and environmental stressors can also reduce students' ability to tap into the mental processes needed to correctly solve maths problems (Mundia, 2012).



However, poor performance due to maths anxiety may not accurately reflect a student's cognitive competence; when the anxiety is relieved, the student's functional ability at maths will emerge (Ashcraft, 2002).

### **Self-esteem**

Self-esteem is an important factor in contributing to a student's academic performance. Self-esteem, as explained by Humphrey (2002), refers to a personal judgment of worthiness that is expressed in the attitudes the individual holds towards him or herself. Students with dyslexia may present low self-esteem for many reasons. It is commonly due to their weak ability in reading, spelling and writing (Glazzard, 2010), which can be compounded if they also face great difficulties in math. Low self-esteem may impact a student's academic achievement when he or she becomes reluctant to put in effort and work hard. On the other hand, students with positive self-esteem tend to work hard towards achieving academic success although they may not always excel. In other words, students with positive self-esteem are willing to persevere and practice in order to improve their maths performance, while students who have never achieved success in maths may stop putting forth effort and will continue to display negative attitudes towards learning math.

### **Method**

Teaching maths to students with dyslexia can be a challenge, especially when teaching maths to students with a language and literacy barrier (Chen & Li, 2008). The aim of this study was to

explore whether prior experience teaching maths had any influence on teachers' ability to teach maths to students with dyslexia. The case study approach was employed as it sought an in-depth exploration of the perception of teachers in order to illuminate the challenges of teaching maths to students with dyslexia.

Random purposive sampling was used, as these teachers were purposefully selected based on the fact that they had (1) three years of teaching experience in literacy at the Dyslexia Association of Singapore (DAS), and that they are (2) currently teaching both maths and literacy classes. Twenty percent of DAS teachers satisfied both criteria and they were selected as the participants for this study.

### **Participants and Setting**

**Setting.** DAS is an organisation that was created 23 years ago to provide literacy support to children with dyslexia. To be eligible for remediation classes at DAS, an educational psychologist must diagnose a child as having dyslexia. Over the years, the DAS has expanded its services to also providing numeracy support to children with dyslexia. Currently, there are eight learning centres providing numeracy support. Participants for this study were chosen from three of these learning centres. The DAS was selected as the study site as the researcher is a teacher at one of the learning centres, and teaches both English and Math.

**Participants.** Three teachers, two female and one male, from the DAS met the study criteria and agreed to participate. All three teachers are dual specialists trained

in both literacy and maths and all have acquired a Diploma in Dyslexia Studies as well as a Professional Certificate in Numeracy Support. The teachers currently teach both literacy and numeracy skills to students who are between seven to 12 years old. These teachers have been given pseudonyms, Ms. Amabel, Mr. Percy and Ms. Rosalie, to ensure strict confidentiality. Ms. Amabel has been teaching literacy skills for 7 years and maths for 5 years. Mr. Percy has been teaching literacy skills for 6 years and maths for 4.5 years. Both teachers had prior experience teaching maths in mainstream schools. Ms. Rosalie, on the other hand, has been teaching literacy skills for 3 years and maths classes for only 5 months.

### Procedure

**Interviews.** The semi-structured interview with all three teachers took place at their respective learning centres. As with all DAS learning centres, each teacher is allocated a classroom to him/herself, thus privacy during the interview process was ensured.

Each interview lasted approximately 45 minutes and was recorded. The interviews were then transcribed and the transcribed data was then sorted and organised according to themes based on four central questions:

1. Do you think that the training you have received is sufficient for you to teach your learners with dyslexia?
2. What do you perceive as the challenges or difficulties you face when teaching math?
3. What do you do to help your students understand maths concepts better?
4. Do you believe your students' difficulty in maths have any impact on their self-esteem?

In total, the interview consisted of seven questions; prompting questions were employed when the researcher needed the participants to elaborate on their responses. Further questions such as, 'Can you be more specific?', 'Please illustrate with examples.' and 'Why are these steps necessary?' were asked if the participants mentioned certain keywords or phrases such as 'training', 'challenges/difficulties', 'understanding maths concepts' and 'confidence/self-esteem'. These keywords and phrases are pertinent to this study as it sought to ascertain the teachers' perception of teaching maths to students with dyslexia.

### Data Analysis

**Qualitative measures.** A qualitative measure is chosen for this study as an in-depth interview is required to understand teacher's perceptions about teaching maths to students with dyslexia. A qualitative study gives these teachers a voice, allowing them to express their viewpoints, providing a rich descriptive detail of the study. Four themes emerged from the interviews with the participants, namely: training, challenges, explicit teaching, and maths anxiety and self-esteem.

### Findings

When asked if they enjoyed teaching math, all three participants replied that

they enjoyed it because teaching maths was fun and fulfilling, especially when the students were able to grasp the concepts and solve maths sums independently. Both Ms. Amabel and Mr. Percy felt that although maths is a challenging subject for students, it is a subject that can be applied to daily life. Ms. Rosalie felt that the structured and logical nature of maths made it exciting to teach.

**Theme 1: Training.** Skipper and Collins (2003) report that teachers who do not receive sufficient training in teaching maths might fall back on the methods that were used to teach them maths and rely on unstructured and incidental instruction that involves minimal teacher interaction or highly structured maths curriculum. Neither of these approaches provided maximum opportunities for students to connect maths concepts to real life in meaningful ways.

All three participants responded that the training they received prior to entering the classroom was insufficient to teach maths to students with dyslexia. As Mr Percy said,

*"For me, I think it is alright because I have been in the education line for many years. But new teachers, no. I think it is not sufficient."*

Indeed, for Ms. Amabel and Mr. Percy, their experience in teaching maths in mainstream schools guided their teaching practices with their students with dyslexia, according to Ms. Amabel,

*"If you were a maths teacher or had exposure in math, then the training given was okay,"*

Having been teachers in mainstream schools, Ms. Amabel and Mr. Percy could readily adopt the approaches that are used to teach maths in mainstream schools and adjust these approaches when teaching students with dyslexia. Ms. Rosalie felt that her experience as a maths tutor during her university years benefitted her in the classroom now. The participants felt that teachers who have never taught maths may need more guidance and extensive research on their own in order to be able to teach maths to students with dyslexia. Ms. Amabel said,

*"I think the teachers need to have the initiative to explore strategies and methods by reading. I think it is very important if they want to be a maths teacher, they have to do a lot of research on the methods that are used in school textbooks."*

Teachers rely heavily on maths textbooks for content and for teaching practice. Therefore, proper training is needed to modify lessons for the individual differences of students with dyslexia, which most maths textbooks do not take into account. As Ms. Amabel pointed out,

*"New teachers have to make comparisons among the different textbooks and pick out methods that are best suited for their students." Mr. Percy elaborated, "I think you need a comprehensive training because we need to know how to tackle the students' difficulties. So the training lies there."*

Extensive research, training, and experience is necessary as teaching approaches may differ among students

with dyslexia. The training that occurs before working with these students is vital for teachers - especially those who have little to no experience in teaching math.

**Theme 2: Challenges.** One of the greatest challenges in teaching maths to students with dyslexia is the specific language of math. Schell (1982) asserted that maths textbooks present the greatest challenge for students to comprehend due to the wide variety of concepts covered. The participants stated that they often have to use simpler vocabulary, paraphrase questions or code switch when explaining certain terms to students. Ms. Amabel explained,

*"So, it is a challenging task for the teacher, for me, to make it easier for them. It has to be done very, very slowly, step by step."*

For students with dyslexia, the language of maths can cause some anxiety and throw them off balance as they grapple with word identification and meaning. Ms. Amabel elaborated,

*" Maths is quite a challenging subject for children. I think they are okay doing computational sums but they find the language in word sums very challenging. Especially in multi-steps sums, they may do a certain portion but they cannot relate the information to another part of the sum."*

Therefore, code switching - alternating between two or more languages, in this case, using the students' mother tongue language, enhances instructional practices. Garegae (2007) found that

explaining concepts in the students' mother tongue gives them a better understanding of the concept(s) and captures their attention. Only after students understand the language of maths are they able to understand maths conceptually.

Another challenge the participants shared were the different types of cognitive styles their students possess. They found that getting "grasshoppers" to record their mental processes on paper was challenging. These students often derive their answers mentally but are unable to work out the procedure sequentially. Grasshoppers also require help to break down their thought processes related to how an answer was derived. All three teachers also found that teaching word problems was challenging due to the necessity of completing maths operations and word decoding to answer questions. Teaching students to identify keywords in word sums is challenging, yet this is a skill that often helps solve word sums.

Additionally, the participants reported that some students have difficulty making connections in word problems, as there could be multiple steps involved in solving a question. Ms. Rosalie summarised the concerns best by stating,

*"In teaching students with dyslexia, there are two areas that we have to deal with. Firstly, it is the operations - plus, minus, times, divide - sometimes they are weak in that, especially their times table. Secondly, it is word sums. The challenge for dyslexic kids is that they involve words and numbers, because in the first place, they can't even understand what the question is asking."*

The students must be able to connect information from one part of the question to another in order to derive correct answers. This is challenging because most students with dyslexia grapple with decoding words they see on paper. Students that spend a great deal of effort and focus decoding words often do not have much mental energy left for comprehending what they have read. Therefore, word sums pose the greatest challenge for these students.

**Theme 3: Explicit teaching.** The participants in this study use the Concrete-Representational-Abstract (CRA) (Witzel, 2005) model to explain certain concepts. This model allows for explicit maths teaching using manipulatives. During the concrete stage, the participants use manipulatives such as blocks, counters and charts to demonstrate concepts to students. The participants reported that their explanations and instructions during this stage were very explicit, as the students have to show the teachers that they have understood the concept which will be assessed through students' worksheets.

The students were then encouraged to use the manipulatives independently when working on additional exercises. The participants found that the hands-on approach in the concrete stage acts as a bridge to the abstract stage. When the students were able to display their understanding, the participants would give similar exercises in the representational form on paper. At this stage, students should be able to relate pictures given in worksheets to objects they had used during the concrete stage. Finally, at the abstract stage, the students

will only be given worksheets with words and numbers to work on. The students must be able to read and comprehend the questions in order to work out the computation, either through a representational form or by calculation. According to Ms. Rosalie,

*"I use the manipulatives, they are very helpful. Recently, I was teaching place value. So I use a chart that states ones, tens, hundreds, thousands and so on. Then I demonstrate using cards with numbers. This is the concrete stage. Then I get my student to choose 4 cards and place them under each place value. I will ask my student what is the place value of each number. If he gets it wrong, I know that he doesn't get it and I will demonstrate to him again because he is not firm with it. Once he gets it, we will move on to the representational stage in the worksheet where I will draw the place value table and get him to write the digits and then tell me their place value."*

As maths is a subject that is applicable in real life, the participants enhanced their students' understanding by relating the concepts to real life situations. Participants felt that students need to understand why they are learning these concepts and how they are used in everyday situations. For instance, when teaching the concept of percentage, Mr. Percy shared that he would relate it to the idea of shopping and sale for his students. He explained,

*"Another example is to make the connections for percentage sign with*

*shopping and sale. And what I did was to get real time examples like paper cuttings or receipts to show them what the percentage symbol means in real life."*

While the concept of fractions is connected to the idea of sharing, Mr. Percy would use counters or objects with his students and get them to share these manipulatives among the class. He would then reiterate the idea of fractions by stating explicitly the terms used in this concept. Additionally, when the students were required to do word sums, the participants would break them down step by step and explain to their students to aid understanding. Mr. Percy explains,

*"The CRA model works very well for them to picture. Using the manipulatives at the concrete stage and then the model drawing at the representational stage will make it easier for the students to after that, understand the abstract stage".*

The use of explicit teaching is necessary for the comprehension of maths according to all the teachers.

#### **Theme 4: Math-anxiety and self-esteem.**

Newbegin and Owens (1996) found that students with high self-esteem reported low anxiety levels and students with low self-esteem reported high levels of anxiety according to Ms. Rosalie,

*"Maths problems create a lot of tension, fear, confusion in my students. So I will start with very simple sums with them and give them a lot to do till they gain confidence and so they won't be so scared. Then*

*the next lesson I will give them slightly more challenging ones but still simple. When they are more firm then I will give them harder questions. So what I do is to improve their confidence first before I give the hard ones"*

The participants in this study felt that all their students displayed anxiety when given maths tasks and often displayed task avoidance or procrastinated. The participants perceived that their students' low self-esteem stems from the students' inability to cope with the rigorous maths curriculum that mainstream schools follow.

In their view, some students with dyslexia feel anxious because they have severe reading difficulty and are unable to do word sums. As Ms. Anabel stated,

*"When the students see their counterparts scoring in maths and they are not scoring in math, it does affect their self-esteem. They feel insecure in that sense. Sometimes they stay away from their friends who are doing well in math. Some of them don't know how to overcome it. This is self-esteem issues. And when it comes to doing work, they will procrastinate because yes, sometimes they are scared to make mistakes".*

However, they are able to do computational sums. When supported by a reader and equipped with decoding skills, these students are able to solve maths sums confidently and feel less anxious. On the other hand, there are students who present comprehension difficulties and thus, require more scaffolding in understanding word sums. For instance, the participants felt that

when they did the word sums together with their students, the students' anxiety level was minimised. They ascertained this when the students showed less resistance to tasks and more confident in attempting questions on their own. This indicated better self-esteem to the participants.

### Discussion

While the need for additional comprehensive training is important for teachers of students with dyslexia, the type of training is also important. According to participants, the challenges mainly exist in understanding word problems and the language of math. Additional training on how to combat student fatigue when working through maths problems would be helpful, as well as how to better explicitly teach certain concepts. Participants also pointed out the need to help students with their self-esteem. Helping students to persevere and persist even when challenged by the "language of math" is a critical component to student success. Understanding techniques and strategies would be helpful according to the participants.

### Suggestions

In order to better prepare teachers for the challenges of teaching those with dyslexia, and in light of the participants reflections, it is important to consider the training currently delivered to pre-service teachers and in-service teachers working with students with dyslexia. First, pre-service training for those entering special schools should be upgraded to include specialised training in maths and maths

difficulties. Currently, there is only one course offered to teachers before they enter specialised schools like DAS. Second, it may be important to establish formal Personal Learning Communities (PLC's) at DAS that can focus on specific challenges in the classroom. As many participants mentioned that self-initiated research was key to learning, this process can be formalised and resources, strategies, and ideas shared between teachers. PLC's have proven to be very successful in Singapore and abroad and can provide powerful learning opportunities for teachers (Darling-Hammond, Chung Wei, & Andree, 2008). Third, if independence in solving maths problems can lead to greater self-esteem as reported by the participants, celebrating these small successes and offering opportunities for independence in the classroom should become part of the curriculum. Teachers and students like to experience success and it is important that a conscious effort is made to acknowledge and praise these successes.

### Limitations

Due to the small number of teachers at the DAS who are trained in math, a reasonable sample size of at least 30 participants could not be gathered. Therefore, responses from the three participants cannot be generalised to the entire population of maths teachers at the DAS and beyond DAS. Furthermore, all three participants in this study had previous experience teaching maths to students without dyslexia. It would be interesting to understand the challenges faced by teachers who do not have any experience in teaching math, but are now teaching maths to students with dyslexia.

The results from this study indicate that the participants do find teaching maths to students with dyslexia challenging, especially when literacy and numeracy skills and knowledge are involved. However, acquisition of maths skills and knowledge during the participants' graduate studies, as well as prior maths teaching experience in mainstream schools, helped the participants teach maths to students with dyslexia. Moreover, participants reported that self-initiated research through books and instructional videos on how to teach math, as well as applying the CRA model in teaching, provided them greater knowledge on how best to teach their students. It is important that continuous training on maths teaching is provided for the benefit of both new and experienced teachers.

One of the most rewarding things for the participants was that their students' self-esteem improved and anxiety level minimised when gaps in maths learning were addressed and they began to attempt to solve questions independently. This is because maths is an accumulated knowledge, when one concept is firm and is built upon with another, students will find it easier to comprehend and make connections. This will in turn render teachers an easier task at imparting new knowledge. Yeo and colleagues (2015) found that the supports given to students to improve their mathematical knowledge are effective and lead to higher self-esteem.

The authors reported significant gains on the students' grasp of all topics that were assessed (Yeo et.al., 2015). This, in turn, contributes to enhanced self-esteem as

students are able to complete maths questions independently and receive higher marks on assessments.

### Conclusion

Further research will be required as the number of teachers trained in and teaching maths at the DAS increases. The purpose of this study was to discover the perceptions about teaching maths to students with dyslexia among three teachers at DAS. The aim was to examine the challenges the teachers and learners faced, the processes teachers undertook to help their students understand maths concepts, and the type of support given to minimise students' anxiety as well as boost self-esteem.

Results indicate that teachers enjoy teaching maths to students with disabilities but find that teaching experience and exposure to multiple teaching strategies are necessary for success. In order to provide more opportunities for success, pre-service training at institutions of teacher education should consider more detailed and comprehensive training for those pre-service teachers who will be working with students with dyslexia. In addition, the use of PLC's at the school and community level and the celebration of small successes can all be valuable to future teaching and learning.

Since the research was undertaken DAS have improved training, mentoring and quality assurance and there will be further investment in core training in 2016.



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## Postscript

### Follow-up from this Article

Following the findings from this study, a follow-up study was initiated by DAS and conducted by the Maths Team and the main author to ascertain if the training provided in the past year and currently have benefitted DAS maths teachers.

A survey was sent out to all Maths teachers and two of the participants involved in the first study were interviewed via email. The interviewees were requested to share if they found any improvements in these trainings.

Both participants indicated the current training that is being provided by Marshall Cavendish to be helpful and will greatly benefit teachers, especially those who are new and have never taught maths to students with learning disabilities. Miss Amabel stated that,

*"There was some internal training by the Maths Team on lesson planning, lesson execution using the CRA approach and the use of resources for the Maths teachers. These trainings were relevant in teaching our dyslexic students. The training by Marshall Cavendish is ongoing to adequately equip Maths teacher with the content knowledge of Maths topics and practical teaching skills."*

Mr Percy, on the other hand indicated that,

*"...so far the Marshall Cavendish programme dealt with strategies on how to help our kids acquire more*

*maths knowledge in order to help them in their classroom work plus model drawing. Seems that this course will be of some help to us in our classroom teaching."*

Furthermore, as a step to continuously provide necessary training for teachers, a Lead teacher from the Maths Team conducts training for newly appointed Maths teachers who will be undergoing Maths practicum. The areas covered are lesson planning, selection of sums and resource utilisation. It is hoped that with this training in place, Maths teachers will be able to conduct their lessons more confidently and competently.

## Reflection

As a teacher of Maths for the past 2.5 years herself, the author had benefitted from the trainings she has received and currently receiving . It has helped the author to gain a better understanding on how maths can be taught to learners which is extremely useful for students with learning disabilities. Apart from having computational difficulties, the language of maths continues to pose a challenge to learners.

Students difficulties in reading are also compounded by their difficulties in comprehending word problems as well. This makes maths learning an arduous process for the learners. By providing a variety of approaches to teach a concept and a more systematic scaffolding technique, the author was able to guide her students more confidently, and in ways that the students understand.

Through this, the author witnessed the

self-esteem and confidence of her students improving as they displayed increasing capability to solve maths questions. The students are also more able to work independently as well as assist peers who require more help.

Hence, in order to help students with disabilities to achieve small successes in math, the content knowledge, capabilities, that a teacher possess is crucial to guide and coach students. Therefore, continuous teacher training must be provided to maths teachers so as to equip them with relevant and necessary skills.