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Evaluating the progress of dyslexic children on a small-group maths intervention programme

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Abstract

Many students with dyslexia have areas of difficulty that can affect their maths performance. These include memory deficits, problems with sequencing, and number reversals. Moreover, their reading deficits and poor comprehension may impact on their ability to solve word problems, a key area in Singaporean maths and in many other countries. Maths is particularly important in Singapore, because success in maths dictates whether a child completes the last 2 years of primary education at Foundation or Standard level. In this article, we present an analysis of the progress of 39 dyslexic children aged 7-11, enrolled with the Dyslexia Association of Singapore, who had completed 6 months support for maths. Support is based on principles used in literacy with a strong emphasis on building concepts to allow word problems to be completed successfully. Pre and post intervention measures of children's maths performance across a full range of curriculum topics were taken. Results show statistically significant improvement in all topics targeted, including addition, subtraction, multiplication, division, time, fractions, geometry, decimals, percentage, and ratio. These results are discussed in relation to the increasing complexity of school maths over the primary phase.

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Introduction:

The main mission of the Dyslexia Association of Singapore is to help dyslexic students to learn to read and write more successfully. It teaches over 2800 students in its 13 Learning Centres. All students have been identified as dyslexic. About 6 years ago, DAS decided to offer a teaching programme specially for our dyslexic students who also experienced difficulties with maths, because of persistent, strong demand from parents of dyslexic children.

Students with dyslexia have specific areas of difficulty that can affect their maths performance: poor short term memory, poor working memory, poor sequencing, reversals, difficulty with reading word problems and poor comprehension and vocabulary stemming from low language ability. In mathematics, these difficulties can impede their ability to understand concepts, compute and apply what they have learned to word problems.

The DAS Maths Programme has grown steadily since its small beginnings, and now supports 250 students in weekly small group classes. It aims to effectively support students with dyslexia who have persistent difficulties in maths, particularly in word problems, by providing dyslexia-friendly lessons while keeping in touch with the mainstream school maths syllabus. As students with dyslexia often have poor vocabulary and comprehension skills due to a late start in reading, word problems are often their biggest area of deficit. As such, the programme works on building a student's maths vocabulary, tying it to concrete manipulatives and pictorial representations. This, coupled with teaching students how to break down word problems, enables students to identify which operation to use in order to solve such questions.

The teaching methodology is based on the needs of the child, with a strong emphasis on concept-building, addressing areas of skill deficit (see Bunn, 2014 for a series of case studies).

The teaching methodology is language based, cognitive, structured, sequential and cumulative, simultaneously multisensory, diagnostic-prescriptive and emotionally sound. These principles, based on experience teaching dyslexics to read and write, are hypothesised to be also appropriate for dyslexics learning maths. In teaching maths, three stages (or levels of representation) are more clearly evident than in teaching reading and writing:

1. **Concrete Stage** – use of tangible manipulatives

2. **Representation Stage** – use of pictures and 2D drawings

3. **Abstract Reasoning Stage** – use of symbols and word to solve problems.

Every stage of learning ensures that the student links mathematical ideas in a progressive and cumulative way. The teaching methodology is multisensory in its delivery and allows students to gain hands on experience with maths concepts. It is imperative that a student is equipped with all the necessary

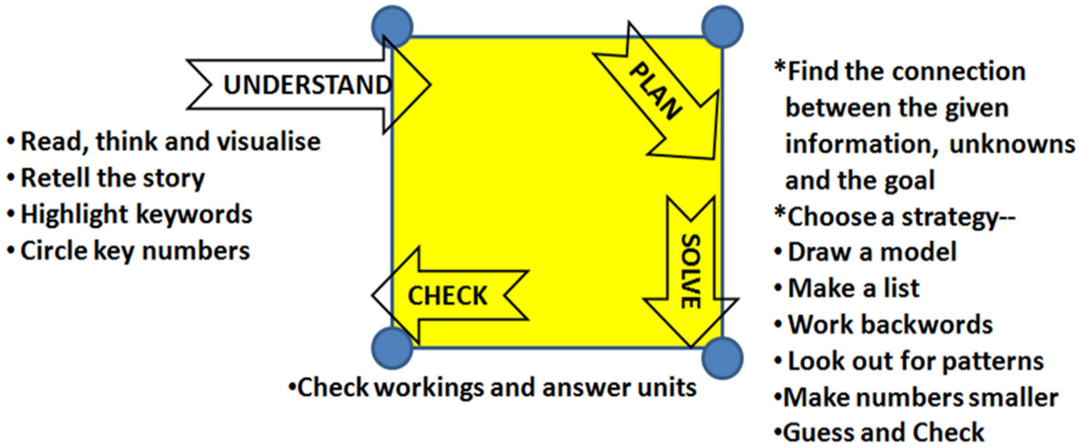

Figure 1. Polya's Four step process approach (1945)

prerequisite skills that he needs but may not necessarily have, in developing his mathematical skills. This would strengthen their foundations for confidence in higher-level maths, building the path towards curriculum based interventions such that the teaching methodology helps to bridge the gap between the student's maths abilities and the school mathematics syllabus.

DAS maths programme students are also taught to solve problems using Polya's Four Step Process approach- understand the problem, plan a strategy, solve the sum and check the workings:

Research on Dyslexia and Maths Learning Difficulties:

Estimates of the prevalence of dyslexia vary, depending on the definitions and statistical cut-off points used, but 3-6% of the general population is perhaps a conservative estimate (Hulme & Snowling, 2009, p38). Estimates for dyscalculia, or maths learning difficulties also vary and are less widely agreed. Shalev's research (Gross-Tsur, Manor & Shalev, 1996)) in an Israeli context suggests 5-7% of the population, and studies in other countries (eg Lewis, Hitch & Walker, 1994, in the UK) suggest a similar range. Research on co-morbidities between these and other learning difficulties now strongly suggests that, far from the expected rate of co-occurrence of 0.3% (5% x 6%), the actual prevalence of children with both difficulties is much higher, perhaps 3%.

A small scale piece of research carried out by DAS in 2012 suggested that of 80 dyslexic children not currently receiving additional help for maths, about a third (36.3%) were in fact weak at maths (scoring below 90 on the Steve Chinn 15 Minute test) (Yeo, Shen & Bunn, 2012). The same study estimated 7.6% of these children had scores below 90 on both word reading and maths calculation tests. These figures form part of the justification for the Dyslexia Association seeking to develop its maths teaching programme.

The nature of and causal explanation for mathematical learning difficulties remains very unclear. Some theories suggest that there is a single fundamental cause: Brian Butterworth, for example, (Butterworth 1999) has argued strongly that a small localised brain region, the horizontal Intraparietal Sulcus (hIPS), functions as a "number module"; other neuroscientists have argued that there are more than one number processing locations in the brain (Dehaene, 2011, p266-271). Other researchers have argued that several general background cognitive processing difficulties, such as procedural learning, semantic memory and visuo-spatial learning difficulties (Geary, 2004) may together explain the variations in maths learning that teachers commonly encounter.

DAS does not espouse one particular theory of mathematical learning difficulties. Our teaching programme, as summarised above, is intended to support the learning of students with as wide a range of maths learning difficulties as possible. It does not screen children for severity or for specific strengths and difficulties (eg. calculation dysfluency or working memory limitations) Some support for our small-group approach comes from a study in Singapore (Kaur & Ghani, 2011) in which over 300 students at the Primary stage were interviewed about their maths learning in small groups; the researchers found that the students expressed clear preferences for working in small groups using manipulatives when learning maths.

The assessment of children's progress in maths usually depends most heavily on performance in public exams and tests, including international comparison studies (eg. Trends in International Mathematics and Science Study (TIMSS) see Kaur 2009). Such tests are intended to say whether a child has learned enough maths, not what difficulty if any they have in learning. Tools for assessing maths learning with a focus on learning difficulties have been developed (eg Key Maths, UK Test of Mathematical Abilities, and TOMA, US). Studies of their value in a Singapore context have suggested that tests from other curricular contexts do not always work well in Singapore (eg Chia & Kho 2011, on TOMA2). DAS's own research did suggest that the Chinn 15 Minute and Calculation Fluency tests (Chinn, 2012) showed very similar patterns of results between UK and Singaporean dyslexics (Yeo, Shen & Bunn 2012).

The DAS maths team wanted to develop a broadly focused maths test whose main purpose would be to evaluate how much learning had taken place topic by topic and stage by stage. The aim was not to differentiate between maths learners or to look for patterns of strengths and difficulties. The test, it was hoped, would both measure progress reliably and be a guide to teaching priorities across topics. The test was evaluated in a short pilot study in 2013 (reported in Bunn, Yeo, Siti Aisha and Abdullah, 2014, p 85-93). The results suggested that the students were making progress (Bunn et al. 2014, p 86). However, the team wanted to evaluate the test more thoroughly, and a study was a carried out to examine the strengths and weaknesses of the test.

Method

Participants

A total of 39 students took part in this study. The participants were Primary 2 (between the ages of 7.5 to 8 years old) to Primary 5 (between the ages of 10.5 to 11 years old) students who were already on the DAS Maths programme at least 6 months at the time of the first testing. All students who did not meet this criterion were excluded from the sample. This is to ensure that all students have had sufficient time to benefit from the programme before we evaluate their performance. The students were from the centres where the DAS Math programme was available at the point of assessment. As of November 2013, the DAS Math programme was only available at six centres.

The breakdown of the sample by grade levels is as follows: 2 students at Primary 2 (P2) level, 11 students at Primary 3 (P3) level, 14 students at Primary 4 (P4) level, 5 students at Primary 5 foundation (P5F) level and 7 students at P5 standard (P5S) level (refer to Figure 2). The grade levels of the students were based on the students' chronological school level at the beginning of the study.

In all primary schools in Singapore, all students would undergo a streaming examination for all subjects at the end of the Primary 4 year (i.e. when an average child is between the ages of 9.5 to 10 years old). The papers for this exam are prepared by the school, with the purpose of evaluating the students' strengths and abilities based on their performance in each subject. The results of this streaming exercise will then be used to guide students' placement into the types of

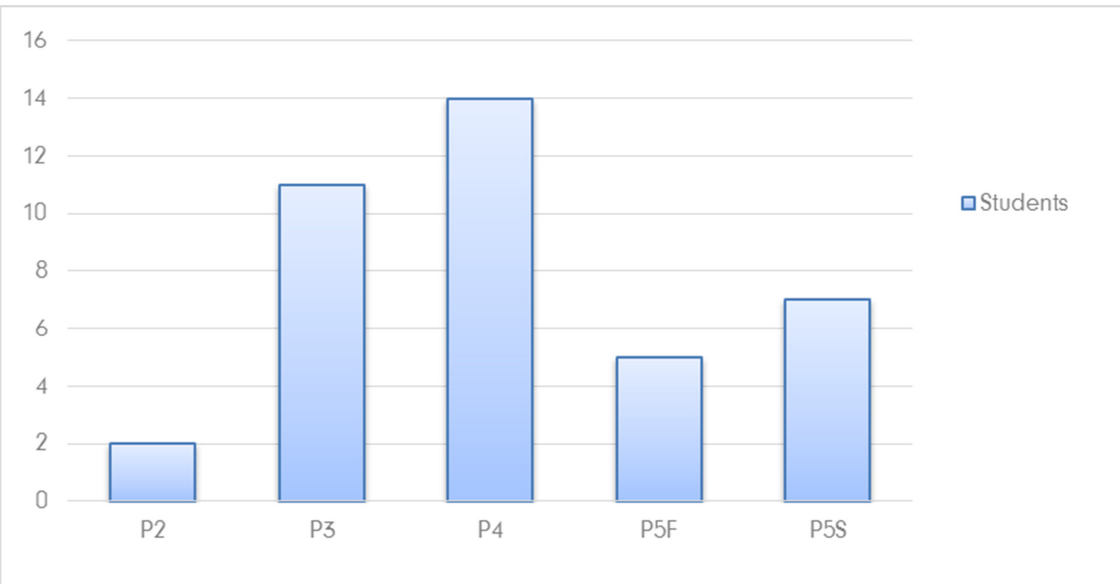

Figure 2. Breakdown of the students by grade levels.

subjects they would take in the remaining two years of their primary school education: Standard or Foundation. Students who have passed at least 3 subjects are allowed to take 4 Standard subjects, while students who have passed 2 subjects or less are given the flexibility to decide whether they would like to take 4 Standard subjects, 3 Standard subjects with 1 other Foundation subject, 2 Standard subjects with 2 other Foundation subjects, 1 Standard subject with 3 other Foundation subjects or 4 Foundation subjects (MOE Communication and Engagement Group, 2014). However, these subject combinations are not set in stone. If a student performs well in one of the Foundation subjects at the P5 level, the school may allow for the student to upgrade one or two subjects to the Standard level if the school believes that the student can cope. On the other hand, for students who seem to be struggling with Standard subjects at the P5 level, the school may also allow for the student to change that subject to that at the Foundation level.

Materials

The students' mathematical conceptual knowledge was assessed using a comprehensive set of topical tests that were previously developed by the maths team, with some guidance from Professor Angela Fawcett and Dr Tim Bunn. The items in this instrument were created with reference to the 2007 Primary Mathematics Syllabus developed by the Curriculum and Planning Development Division of the Ministry of Education, Singapore (2006). We decided to use our in-house test because published maths tests do not cover the Singapore maths syllabus fully, and do not reflect the balance of computational and word problems that Singaporean students face. Moreover, we wanted to be able to identify topic by topic what concepts students had learned and still needed to work on. This collection of tests, known as the Annual Testing papers, assesses ten topics (addition, subtraction, multiplication, division, time, fractions, geometry, decimals, percentage, ratio) and covers calculations and word problems separately within each area.

The test was broken down by grade level (i.e. Primary 1 to Primary 6) such that students only need to attempt the items for their grade level and one grade below. Based on the Singapore mathematics curriculum, certain topics were only introduced from a certain grade level onwards (e.g. Decimals is only introduced from Primary 4) and thus were not tested for students who had not yet learned the topic because of the grade level they were in (e.g. Primary 3).

In addition, students were assumed to have attempted the items that are two grades or more below their grade level correctly, and thus these items were not included in their test paper. For example, a Primary 5 student would be assumed to have attempted the items at the Primary 1, Primary 2 and Primary 3 levels correctly even though he did not do the questions. The test provides measures of learning on each concept. It also guides teaching as it enables therapists to show which grade level their students are working on within each topic and whether there is more to do at that level.

Procedure

Students were administered the first test in November 2013 and then a copy of the same test six months later (May 2014). The tests were administered during one of the Math lessons within the school term so as to reduce the logistics problems related to data collection. The test was not timed but students were allowed a maximum of two hourly sessions to complete the test. While students were doing the test, the teachers in charge had to walk around to check the final answers of each question. If the final answer was correct, the student could proceed forwards to attempt the next question. However, if the final answer was incorrect, the teacher had to direct the student to try the question before. The testing on a topic will be discontinued if the student has three consecutive questions incorrect or if they have reached the end of the section. At the end of the entire test, teachers will mark the students' responses using the answer scheme that has been provided and input the number of errors the student has made into a Microsoft Excel file. A percentage score would be calculated automatically by the Excel document that can be used for statistical analysis.

Results

Before the data was analysed, it was first cleaned by checking for scores that fell outside the range of possible scores. The range of possible scores is defined as the scores between the lowest possible score for each grade and topic and the highest possible score for each grade and topic. Calculation of the range depended on the total number of items that the students were assumed to have attempted, and the total marks allocated for these items. A total of 27 scores were found to have fallen below the range of possible scores. These scores were adjusted to the lowest possible score as per the grade level of the student.

Using the clean data, the students' pre-test and post-test scores were compared using a one-tailed matched samples t-test. The data was evaluated on two levels: (a) by topic, and (b) by level.

Students' progress across the topics

On the whole, regardless of the grade levels students were in, the results showed that there was significant improvement across all ten topics. Table 1 summarises the students' performance across the topics.

Students' progress across grade level

Students' progress at the P2 level

The Primary 2 students were only required to attempt a total of 7 topics, based on the school curriculum. These topics include addition, subtraction, multiplication, division, time, fractions and geometry. The analysis also revealed that there was no significant improvement in their scores when the topics were looked at as a whole ($t(6) = .003$, $p=.50$). The comparison of their scores across topics is documented in Table 2. No significant differences were observed in any of the topics at the $p<.05$ level. However, scores improved or remained steady on 4 out of 7 topics, with the greatest improvement in division.

Table 1 — Students' progress across the topics

	Pre-test scores		Post-test scores			
Topic	*M*	*SD*	*M*	*SD*	*t-score*	*p*
Addition	83.60	14.11	88.44	11.20	$t(38) = 2.29$	.01*
Subtraction	75.86	22.33	83.58	17.85	$t(38) = 1.92$	.03*
Multiplication	79.82	16.56	89.75	11.51	$t(38) = 4.07$	<.001***
Division	66.55	23.09	84.48	17.51	$t(38) = 5.67$	<.001***
Time	72.36	18.41	81.32	19.21	$t(38) = 3.48$	<.001***
Fractions	58.79	23.47	77.62	22.85	$t(38) = 4.35$	<.001***
Geometry	72.25	25.41	81.88	24.82	$t(38) = 2.84$	.003**
Decimals	45.46	13.36	65.93	34.04	$t(25) = 3.61$	<.001***
Percentage	36.00	35.93	70.86	20.39	$t(6) = 2.66$	.002**
Ratio	57.80	42.12	92.81	3.38	$t(6) = 2.23$	.03*

Note. *p <.05. **p <01. *** p < .001

Table 2 - Progress of P2 students across the topics

	Pre-test scores		Post-test scores			
Topic	*M*	*SD*	*M*	*SD*	$t(1)$	*p*
Addition	90.90	0	95.45	6.43	1.00	.25
Subtraction	75.00	7.07	80.00	0	1.00	.25
Multiplication	100.00	0	100.00	0	N.A.	N.A.
Division	57.80	42.00	93.75	8.84	1.53	.18
Time	77.80	15.70	72.25	7.85	1.00	.25
Fractions	83.35	23.55	47.20	66.75	0.06	.34
Geometry	100.00	0	96.00	5.66	1.00	.25

*Note. *p <.05. **p < .01. *** p < .001*

Table 3 — Progress of P3 students across the topics

	Pre-test scores		Post-test scores			
Topic	*M*	*SD*	*M*	*SD*	*t*(10)	*p*
Addition	87.88	11.85	91.65	10.55	0.85	.21
Subtraction	76.02	22.74	81.81	23.00	0.87	.20
Multiplication	77.91	23.01	93.35	9.40	2.38	.02*
Division	59.70	33.58	80.99	26.79	2.95	.007**
Time	60.91	21.89	77.27	23.49	2.21	.03*
Fractions	51.64	30.62	75.19	26.06	2.99	.007**
Geometry	72.1	21.92	86.00	20.59	1.90	.04*

Note. *p <.05. **p < .01. *** p < .001

Table 4—Progress of P4 students across the topics

	Pre-test scores		Post-test scores			
Topic	*M*	*SD*	*M*	*SD*	*t*(13)	*p*
Addition	80.11	17.52	84.18	11.63	1.11	.14
Subtraction	70.42	23.79	77.26	18.43	0.84	.21
Multiplication	76.07	14.76	82.39	12.94	1.81	.046*
Division	63.51	14.73	80.94	13.24	4.17	<.001***
Time	68.54	14.36	72.17	16.80	1.43	.09
Fractions	50.36	18.38	73.68	16.52	5.08	<.001***
Geometry	54.06	25.96	62.91	28.11	1.22	.12
Decimals	26.94	23.39	46.04	35.48	2.12	.03*

Note. *p <.05. **p < .01. *** p < .001

Table 5—Progress of P5F students across the topics

	Pre-test scores		Post-test scores			
Topic	*M*	*SD*	*M*	*SD*	*t*(4)	*p*
Addition	78.54	16.02	82.86	14.82	0.59	.29
Subtraction	90.00	6.74	89.08	7.61	0.30	.39
Multiplication	87.60	11.61	98.66	3.00	2.61	.03*
Division	79.98	13.95	89.98	9.15	1.18	.15
Time	86.66	11.18	94.16	5.59	1.50	.10
Fractions	70.46	13.61	92.52	10.24	2.82	.02*
Geometry	89.98	12.09	98.46	3.44	1.83	.07
Decimals	60.90	21.92	88.66	3.43	2.85	.02*

Note. *p <.05. **p < .01. *** p < .001

Table 6—Progress of P5S students across the topics

	Pre-test scores		Post-test scores			
Topic	*M*	*SD*	*M*	*SD*	*t*(6)	*p*
Addition	85.37	9.28	93.90	4.93	2.01	.046*
Subtraction	76.63	28.18	96.10	7.16	1.70	.07
Multiplication	78.97	8.06	89.53	8.48	2.26	.03*
Division	76.31	14.45	90.47	12.20	1.96	.049*
Time	86.24	9.91	99.40	1.59	3.67	.005**
Fractions	71.56	14.65	87.39	10.96	3.30	.008**
Geometry	88.29	11.82	97.46	4.47	2.70	.02*
Decimals	71.49	30.57	89.47	34.04	1.87	.055
Percentage	36.00	35.93	70.86	20.39	2.66	.02*
Ratio	57.80	42.11	92.81	3.38	2.23	.03*

Note. *p <.05. **p < .01. *** p < .001

Students' progress at the P3 level

The P3 students showed significant progress in all topics at the post-test level except for addition ($t(10) = 0.85$, $p = .21$) and subtraction ($t(10) = 0.87$, $p = .20$). Table 3 summarises the results of the students at the P3 level. A significant improvement was also observed when all the topics were studied collectively ($t(6) = 5.15$, $p < .01$).

Students' progress at the P4 level

At the P4 level, decimals is introduced as a new topic. Thus, a total of eight topics were assessed at the P4 level. Significant improvements were only observed for four topics: multiplication (t(13) = 1.81, $p < .05$), division ($t(13) = 4.17$, $p < .001$), fractions ($t(13) = 5.08$, $p < .001$) and decimals ($t(13) = 2.12$, $p < .05$). As a whole, a significant improvement was observed in the post-test ($t(7) = 4.17$, $p < .001$). Table 4 summarises the results of the students at the P4 level.

Students' progress at the P5F level

Students in the P5F level were assessed on the same topics as the P4 students. Students in the P5F level are considered to require more help with their mathematics foundation as compared to their peers in the P5S level. Therefore, in the Singapore Mathematics curriculum, P5F students are exempted from two new topics that are introduced at the P5S level, namely Percentage and Ratio.

Data analyses show that the P5F students improved significantly in three topics: multiplication ($t(4) = 2.61$, $p < .05$), fractions ($t(4) = 2.82$, $p < .05$) and decimals ($t(4) = 2.85$, $p < .05$). When all the topics were considered as a whole, a significant improvement was observed at the post-test level ($t(7) = 3.42$, $p < .01$). Table 5 summarises the results of the students at the P5F level.

Students' progress at the P5S level

Students in the P5S level were assessed on the greatest number of topics. Data analyses show that the P5S students showed significant progress in their scores in all topics except for subtraction ($t(6) = 1.70$, $p = .07$) and decimals ($t(6) = 1.87$, $p = .055$). When all the topics were considered as a whole, a significant improvement was observed at the post-test level ($t(9) = 5.90$, $p < .001$). Table 6 summarises the results of the students at the P5F level.

Discussion

The objective of this study was to objectively measure the progress of the students in the DAS Maths program to see if our program is effective in improving the mathematical knowledge of our students. The results showed that students generally made significant improvements in their knowledge of all the topics that we have assessed them on. However, when we scrutinise the results by grade level, we find that the amount of progress the students made varied by topic, as well as across levels. There appears to be a steady decline in the number of topics where improvements are observed from P3 to P5F. One factor that could account for this decline is the increase in difficulty of the topics as one progresses through the school system. While our program aims to help students to understand concepts within their zone of proximal development and at their learning pace, schools are teaching students concepts that are getting increasingly complex. Therefore, we find that although they do show some improvement, the students are still not matching up to their expected school standards.

There are also some unexpected trends in the results that are worthy of mention. First is the finding that the P2 students did not make any significant progress in any of the topics. There are several reasons to account for this. First and foremost, the sample size is too small for the results to be valid in explaining trends in a population. A bigger sample is needed to test if our intervention is effective at the P2 level. Secondly, due to the small sample size, a change in one of the participants' scores is likely to affect the overall mean and standard deviation of the scores significantly, which was what happened in the dataset. However, we also noticed that there was an anomaly in one of the students' scores. In this case, the student was observed to have regressed in his performance in the topic of Fractions. We approached the teacher of this student to try and investigate why this was so. We learned that the most probable explanation for this is due to a long time lapse of more than 6 months between the time he had learned Fractions in P2 (pre-test) and the time that his school had covered Fractions again in P3. This finding highlights the difficulties that some of our students with dyslexia encounter in schools which follow a spiral curriculum. One of the characteristics of dyslexia is a difficulty of retrieving information from long-term memory. By the time of the post-test, the student had already forgotten what he had learned about Fractions at the P2 level and his school had only just began to teach Fractions at the P3 level. This was probably why he did not perform as well as he did during the post-test 6 months ago.

There were also limitations to the design of the study and areas we could improve on. Firstly, we did not check which topics were already covered by our teachers at each testing. Matching the topics teachers had already covered with the progress of students would give us a more accurate picture of the effectiveness of our program. This could also explain why students improve in certain topics not in others. Second, we were unable to form a control group in this design because we did not have ready access to students not on our maths programme. Nor did we control for other extraneous and mediating variables such as the number of hours students receive other forms of mathematics remediation (e.g. tuition) outside of our program. Therefore, we were unable to determine if the results were entirely due to our programme or due to other factors. If we had controlled for other factors, we would perhaps be able to conduct a factor analysis to identify the main contributors to our students' improvements. Finally, the test was not being timed even though students could take a maximum of two hours to complete it. Thus, their results may not be an accurate reflection of their performance in school-based examinations where they have to complete their paper within a stipulated time limit. In future research it would be useful to check how much they could complete within a fixed time period, as well as allowing them as much time as they need to complete the test.

Conclusions

The main aim of the study was to evaluate the use of a comprehensive test of Singaporean primary maths as a measure of progress for dyslexic students on the DAS small group maths intervention programme. The study shows that students made significant improvement across all topics covered by the test. Analysis grade by grade shows that at each grade level some topics show much greater improvement than others, with fewer topics showing progress at higher grades. This may be a result of harder topics being introduced later in the primary phase, and there may also have been less progress because of poor retention when topics were taught a longer time before the test.

The test is considered to be a useful instrument, but the DAS maths team may need to consider alternative test designs to see if other ways of testing would be equally or more efficient. We may also need to consider ways to recruit non-intervention children as controls to measure the unique contribution of the programme.

Future Directions

To help our very weak students who are struggling with basic math concepts, the team is currently compiling a set of differentiated lesson plans and strategies that are catered towards helping our weaker students with their number sense, a fundamental skill for grasping mathematical concepts. This will be integrated into the current Essential Maths programme to help our teachers reach out to students with diverse math abilities.

Currently, our annual assessment of students' progress takes approximately one to two hours to complete. In the team's opinion, this is too long a duration, and students do report feeling unmotivated to finish the paper. Some have even displayed task avoidance. Based on the feedback, the team will look into how to shorten the test without affecting its psychometric properties. We will continue to uphold the high standards in teaching quality as well as the professional development of our dual specialists through in-house training (insets) and workshops. The teaching standards of our existing dual specialists will be monitored by a peer dual specialist and one of the core team members using video observations of a lesson, once every year.

References

Bunn, T. (2014). Mathematical difficulties in Singapore: a case study approach. *Asia Pacific Journal of Developmental Differences, 1*, 90-113.

Bunn, T., Yeo, R., Siti Aishah B. S., Abdullah, A. (2014). Specialised Educational Services - Essential Maths Programme. In A. Fawcett (Ed.), *DAS Handbook 2014*, Singapore: Dyslexia Association of Singapore.

Butterworth, B. (1999). *The Mathematical Brain*, London: MacMillan

Chia, N. K. C, & Kho, C. P. (2011). An Investigative Study on the Learning Difficulties in Mathematics Encountered by Primary 4 Children: In Search of a Cognitive Equation for Mathematics Learning. *Journal of the American Academy of Special Education Professionals* (JAASEP), Winter 2011, pp 93-119

Chinn, S. (2012). *More Trouble with Mathematics.* London: NASEN/ Routledge

Dehaene, S. (2011). *The Number Sense,* Oxford University Press: New York

Geary, D. C. (2004) Mathematics and Learning Disabilities. *Journal Of Learning Disabilities, 37,* pp 4-15

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

Hulme, C. & Snowling, M. J. (2009). *Developmental Disorders of Language and Cognition*, Oxford UK: Blackwell Publishing.

Kaur, B. (2009). Performance of Singapore Students in Trends in International Mathematics and Science (TIMSS), in Wong K. Y., Lee P. Y., Kaur B., Foong P. Y., & Ng S. F. (2009). *Mathematics Education: The Singapore Journey*, Singapore: World Scientific Publishing.

Kaur, B. & Ghani, M. (2011). Learning Experiences of Singapore's low attainers in primary mathematics. *Mathematics: Traditions and (new) practices*. Singapore: AAMT & MERGA

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*, pp 283-292

Polya, G. (1945). *How to solve it.* Princeton: Princeton University Press. ISBN 0-691 -08097-6.

Yeo, C., Pixin, P., S., Bunn, T. (2012). An Investigation of Dyslexia and Maths Difficulties in Singapore. Unpublished conference presentation, *Maths Learning Differences and Dyscalculia Conference*. Singapore: Dyslexia Association of Singapore.