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A CASE STUDY OF A CHILD WITH ATTENTION DEFICIT/HYPERACIVITY DISORDER (ADHD) AND MATHEMATICS LEARNING DIFFICULTY (MLD)

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Abstract:
This is a case study of a male child, EE, aged 8+ years, who was described as rather disruptive in class during lesson. For past years, his parents, preschool and primary school teachers noted his challenging behavior and also complained that the child showed a strong dislike for mathematics and Chinese language – both are examinable academic subjects. As a result of the disturbing condition, EE was referred to an educational therapist at a private intervention center for a diagnostic assessment. The child was identified with Attention Deficit-Hyperactivity Disorder (ADHD)-Combined subtype. This aim of this paper is to discuss about the effects of ADHD on mathematics learning and how to avoid misdiagnosis or over-diagnosis of a behavioral-cum-learning disorder.

Keywords: attention deficit/hyperactivity disorder, dyscalculia, mathematics learning difficulty

1. Introduction

Children who are affected by ADHD often struggle learning mathematics (or math for short) because their memory is weak and they find it difficult to block out external stimuli (Rosenfeld, 2019). Many of these children also do not possess strong or good executive function skills and as such, their academic performance in class/school is significantly

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[ii] Twinkle Intervention Center (TIC) has been bought over by Best Learning Center (BLC) since September 2019. This paper was completed before the center was transferred to the BLC management, which has agreed with the authors' request to retain the TIC name for this paper.

impacted. It is common for these children with ADHD to have working memory impairments which, in turn, can impede a child's ability to do this. Deficits in working memory make it difficult for a child to hold information in his/her head and keep track of that information while performing the multiple steps involved in many mathematical computations (Low, 2016; Rosenfeld, 2019).

According to Rosenfeld (2019), there are three key struggles for children with ADHD in their math learning. In the first struggle, children with ADHD find reading, understanding and solving word problems overwhelming. For these children with ADHD, "*the stumbling block with word problems lies in the combination of words and numbers that make it difficult to store the information in their memory as they progress through the problem*" (Rosenfeld, 2019, para.12) and even if the child *"… is able to follow along with the problem, when it comes time to solve it, all of their energy and focus is already used up!"* (Rosenfeld, 2019, para.13). In the second struggle, these children find the order of arithmetical operations confusing. The acronym PEMDAS, which stands for Parentheses, Exponents, Multiplication, Division, Addition, Subtraction, is supposed to help these children with ADHD recall the order of operations in complex math problems. "Th*e struggle that students with ADHD have with math problems that require them to conjure up the correct order of operations has to do with their working memory and ability to maintain focus throughout the multiple problem-solving procedures*" (Rosenfeld, 2019, para.19). In the third and last struggle, children with ADHD find it very tough to stay focused long enough to finish the math problem. Other than the working memory problems, these children also encounter challenging issues with focus. That is the key reason why so many children with ADHD tend to struggle with math problems. Rosenfeld (2019) argues that "*[S]taying intently focused on a single task takes a ton of mental energy, which often conflicts with the desire that many kids with ADHD have for constantly changing stimulation. This is why completing a mathematical proof, a complex word problem, or a problem involving intricate problem-solving procedures can seem out of reach for your child*" (para.25-26).

In this paper, the authors want to share a case study of an eight-year-old Chinese boy, EE[iii], with disruptive behavior and suspected mathematics learning disability (MLD). His teachers saw him as a naughty child who often disrupted class lessons and not getting along well with his classmates. It was only after the child's parents sent him for a diagnostic assessment, did they realize that EE has shown signs and symptoms of ADHD as well as poor attitude toward math learning (and also display negative attitude toward learning Chinese language).

2. Case Study

2.1 Brief Background of the Client

EE, aged 8 years 8 months, is a boy of Asian (Chinese) descent from Teochew speaking dialect group, born in Singapore. He is the only child in his family. His parents speak

[iii] Not the exact initials of the client's actual name. The anonymity of client has to be kept due to the Personal Data Protection Act 2014 introduced in Singapore.

English and Mandarin at home. His father works as a sales executive while his mother is a private tutor. Currently, EE is studying in primary 3 at a mainstream government-aided primary school.

Since his pre-school years, his preschool teachers had complained about his disruptive behavior during class lesson. EE often disturbed his peers who would complain to the teachers. According to the child's parents, EE did not have friends in his preschool class. Feedback from his preschool teachers indicated that EE could pay attention and complete activities (e.g., physical education, nature study, arts and craft) that were of interest to him.

More complaints came when EE began his primary school education. From Primary 1 until the current grade, EE's form teachers as well as other subject teachers, especially mathematics and Chinese language, have been complaining of his inattentiveness, easily distracted, impulsiveness and does not stay in his seat. EE is easily bored and will move about in class even during lesson. Now in Primary 3, EE is often late in his homework submission and is unable to complete his written assignments done in class. Hence, he often misses his recess and has to complete his written work in class. By the time he is done, the recess is over, and he would complain that he is hungry and cannot stay focused during the post-recess lesson. EE is punished and the teacher would make him stand or sit in the naughty chair at the back of the classroom. Despite his challenging behavior, EE is able to answer questions whenever he is asked by his teachers.

However, as mentioned earlier, EE's weakest subjects in school or class are his mathematics and Chinese language. He does not like these two examinable subjects because he feels they are boring. He has been failing in his Chinese language but manages to pass his mathematics with a borderline grade. EE often tries to avoid studying Chinese language by giving all kinds of excuses and/or doing mathematics worksheets by complaining that he is not feeling well or having a bad headache or stomachache.

As a result, his parents were recommended by the school counselor to have EE assessed for the possibility of having challenging behavior, and perhaps, also learning difficulties. EE's parents came to Twinkle Intervention Center after they found it online. The parents called up the center, which set an appointment for them to meet for an initial consultation. After the consultation session, another date and time were given for EE to be seen and assessed by a psychologist or an educational therapist.

3. Diagnostic Assessment

According to Brummitt-Yale (2017), diagnostic assessment is defined as "*a form of pre-assessment that allows a teacher to determine students' individual strengths, weaknesses, knowledge, and skills prior to instruction. It is primarily used to diagnose student difficulties and to guide lesson and curriculum planning*" (para.3). Diagnostic assessments provide teachers the necessary information about a student's prior content knowledge, required academic skills and misconceptions of a subject (e.g., mathematics) before beginning a learning activity. They can also be used to provide a baseline for understanding how much learning has taken place after the learning activity is completed. Teachers usually build concepts sequentially throughout the course of an academic subject they teach.

In the case of EE, only three tests were administered: (1) Wechsler Intelligence Scale for Children-4th Edition (WISC-IV) (Wechsler, 2003), (2) Test of Mathematical Abilities-2nd Edition (Brown & McEntire, 1984), and (3) Mathematics Attitudes & Perceptions Survey (MAPS) Questionnaire (Code, Merchant, Maciejewski, Thomas, & Lo, 2016). These three assessments constitute the diagnostic battery assessment (DBA) to find out EE's learning and behavioral issues of concern. This is certainly very different from the standard assessment protocol carried out by an intervention center, which adopts the cross-battery assessment (X-BA). The X-BA is a process by which assessors use information from multiple test batteries to help guide in their diagnostic decisions and to gain a fuller picture of an individual's cognitive, conative, affective and sensory abilities and skills than can be ascertained through the use of multiple-battery assessments of the same block of abilities and skills or single-battery assessments (Flanagan & McGrew, 1997).

First introduced in the late 1990s, the X-BA offers practitioners (i.e., psychologists and therapists) the means to make systematic, valid and up-to-date interpretations of intelligence batteries and to augment them with other tests in a way that is consistent with the empirically supported Cattell-Horn-Carroll (CHC) theory of cognitive abilities (Flanagan, Ortiz, & Alfonso, 2007).

In order to decide which tests to be included in the X-BA plan, the assessment team will review selected tests after due consideration has been given in the context of the client's condition based on parents' and teachers' feedbacks. Next, once the selected tests have decided on, they follow the Hierarchy of Building Blocks of Abilities and Skills postulated by Chia (2008, 2012) as a framework (see Figure 1 below) for X-BA.

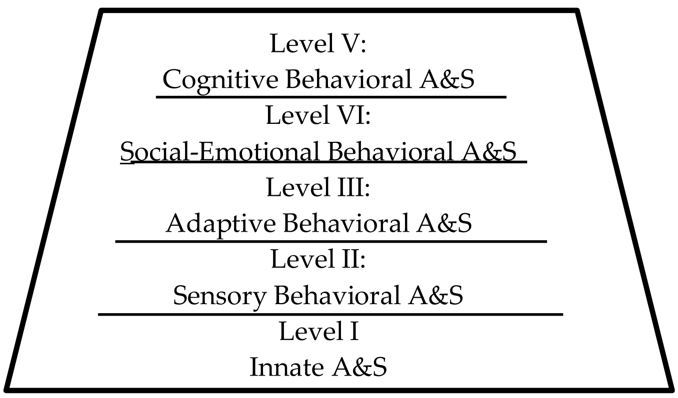

Figure 1: Hierarchy of Abilities and Skills

There is a difference between skills and abilities. In fact, skills are abilities. However, a skill is a composite of abilities, techniques and knowledge (DB.net, 2018; Julita, 2011). They are the ones that make a person do tasks at a higher degree or standard with goal-oriented expectations of improvements or positive changes in an individual's performance.

DB.net (2018) and Julita (2011) have provided a brief summary of skills and abilities:

1) A skill is acquired. On the other hand, an ability is more of constitutional origin or inherited.
2) A skill can be practiced to perfection but not the ability, which an individual either possesses or not. For instance, talent is an ability, not a skill.
3) As a skill is goal-directed, it expects an individual to attain a higher level of performance. However, unlike the skill, an ability does not necessarily equate to exceptional performance.
4) An individual's level of functionality depends more on ability than skill.
5) An ability is more stable than a skill.

Whether a child can perform well academically depends on the hierarchy of skills and abilities as mentioned earlier above. However, returning to EE's case, the DBA differs from the X-BA in that only one standardized test from Block I and two from Block V were selected for administration. The reason was that the parents of EE were only more concerned about their child's academic performance and his disruptive behavior during lesson in class.

Table 1 shows the various standardized tests that were selected for administration.

Table 1. Hierarchy of Building Blocks of Abilities & Skills

Hierarchy of Blocks	Abilities & Skills (A&S)	Primary Measure (PM)	Supplementary Measure (SM)	Additional Measure (AM)
Block 1	Innate A&S	WISC-IV	--	--
Block 2	Sensory Perceptual-Motor Behavioral A&S	--	--	--
Block 3	Adaptive Behavioral A&S	--	--	--
Block 4	Social-Emotional Behavioral A&S	--	--	--
Block 5	Cognitive Behavioral A&S	TOMA-2	MAPS-Q	--

Key: WISC-IV=Wechsler Intelligence Scale for Children-4th Edition; TOMA-2=Test of Mathematical Abilities-2nd Edition; and MAPS-Q=Mathematics Attitudes & Perceptions Survey-Questionnaire.

Below is a brief description for each of the building block of abilities and skills:

- Block I-Innate Abilities & Skills:

This is also known as the Foundation Block refers to the core block of an individual's innate abilities which deal with the use of language to communicate, abstract thoughts and reasoning skills, memory retention as well as problem solving skills. An example of an assessment tool for this level is an IQ test such as Wechsler Intelligence Scale for Children-4th Edition (WISC-IV) (Wechsler, 2003).

- Block II-Sensory Behavioral Abilities & Skills:

Block II focuses on the sensory-perceptual-motor coordination and related behavioral abilities and skills involving balance/motion of the body (vestibular) & position of body (proprioception). An example of an assessment tool for this level is the Sensory Profile (Dunn, 1999).

- Block III-Adaptive Behavioral Abilities & Skills:

Block III concerns the adaptive behavioral abilities and skills, such as activities of daily living, social interaction, communication, self-help skills (e.g., toileting, dressing, bathing), personal hygiene and other related practical skills. An example of an assessment tool for this level is the Adaptive Behavior Diagnostic Scale (Pearson, Patton, & Mruzek, 2006).

- Block IV-Socio-Emotional Behavioral Abilities & Skills:

Block IV consists of socio-emotional behavioral abilities and skills which cover adaptive, internalizing and externalizing behavioral skills. This level of skills and abilities can also be determined by assessment tools such as ADHD Rating Scale-IV (DuPaul, Power, Anastopoulos, & Reid, 1998) and Gilliam Autism Rating Scale-2nd Edition (GARS-2) (Gilliam, 2006).

- Block V-Cognitive Behavioral Abilities & Skills:

Block V focuses more on academic or educational attainments, which include higher levels of cognition, involving word knowledge (i.e., active and passive vocabularies), general knowledge, ability to count and perform operational functions involving numbers and ability to carry out activities using both verbal and nonverbal reasoning skills. Most of the assessment tools are academic attainment measures, such as Mathematics Attitudes and Perceptions Survey-Questionnaire (Code et al., 2016), Test of Mathematical Abilities-2nd Edition (Brown, Cronin, & McEntire, 1994), and Renfrew Language Scales (Renfrew, 2019).

4. Results and Discussion

In this section, the results obtained from the administration of the three measures are discussed in detail below, beginning with the IQ test results based on the WISC-IV administration, and followed by two other measures on math learning (based on the TOMA-2 administration) and attitude toward math learning (based on the MAPS-Q administration). The authors want to reiterate that the three measures constitute a diagnostic battery assessment and should not be considered as a cross-battery assessment. More detail will be discussed here.

4.1 Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV)

The WISC-IV (Wechsler, 2003) is a norm-referenced, individually administered measure of intellectual capacity. Its results provide a measure of general intelligence (also known as Full-Scale IQ or FSIQ for short) as well as more specific measures of Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI) and Processing Speed Index (PSI).

EE's assessment was completed in two separate sessions (with one day apart), as the child as restless and uncooperative as the assessment went on for nearly an hour. Although appearing a little anxious at first, EE was soon at ease with the testing process, and participated enthusiastically in every task during the second session. He attempted his best to answer every question given to him, and this would suggest that the results were a good reflection of his true abilities.

EE was assessed using the WISC-IV (Wechsler, 2003), which is a standardized test of intellectual ability used with children. The WISC-IV examines functioning on a range of subtests, which constitute four index scores as mentioned earlier, i.e., VCI, PRI, WMI and PSI. The VCI measures verbal concept formation by assessing a child's "*ability to listen to a question, draw upon learned information from both formal and informal education, reason through an answer, and express their thoughts aloud*" (Sandhu, 2019, para.6). The PRI measures non-verbal and fluid reasoning by assessing a child's "*ability to examine a problem, draw upon visual-motor and visual-spatial skills, organize their thoughts, create solutions, and then test them*" (Sandhu, 2019, para.7). The WMI measures, of course, the working memory by assessing a child's "*ability to memorize new information, hold it in short-term memory, concentrate, and manipulate that information to produce some result or reasoning processes*" (Sandhu, 2019, para.8). The PSI measures, of course, the processing speed by assessing a child's "*ability to focus attention and quickly scan, discriminate between, and sequentially order visual information*" (Sandhu, 2019, para.9). To do well in the PSI subtests, it requires persistence and planning ability. It is also sensitive to motivation, difficulty working under a time pressure, and motor coordination, too (Sandhu, 2019).

Table 2 shows a summary of EE's composite scores. His FSIQ of 98 at 45%ile rank put him in the category of average general intelligence. Among the four WISC-IV indexes, EE scored worst for his WMI with a standard score of 77 at 6%ile rank within the borderline range of scores indicating that he certainly requires some specialized intensive intervention. That means the child is provided additional support from a specialist teacher who teaches only mathematics.

Table 2. A Summary of WISC-IV Composite Scores

WISC-IV Indexes (I)	Sum of Scaled Scores	Composite Score	Percentile Rank	95% Confidence Interval	Qualitative Description
Verbal Comprehension (VCI)	22	85	16	79-93	Low Average
Perceptual Reasoning (PRI)	39	119	90	110-125	High Average
Working Memory (WMI)	12	77	6	71-86	Borderline
Processing Speed (PSI)	24	112	79	102-120	High Average
Full-Scale IQ (FSIQ)	97	98	45	93-103	Average

Next, EE's VCI of 85 at 16%ile rank put him in the low average range suggesting that he also needs Tier-2 intervention according to the Response to Intervention (RTI) initiative. Children who are not making progress in Tier-1, which often involves differentiated instruction, usually get Tier-2 help, which involves small group lessons two to three times a week, using evidence-based strategies taught by a resource teacher or special teacher. In Singapore, an allied educator (i.e., a para-educator) trained in providing learning and behavior support is called in to facilitate the child's learning in class as well as teach him/her in pull-out sessions. EE still takes part in regular lessons with the rest of the class while getting Tier-2 support.

For PRI and PSI, EE obtained high average standard scores for both indexes. His overall IQ or FSIQ of 98 at 45%ile rank put him within the average range. According to Cooijmans (n.d.), there are two subcategories of average IQ: (i) 90-99 and an individual whose FSIQ falls within this range is able "*to learn a vocational trade in a hands-on manner and perform tasks involving decisions*" (para. 13); and (ii) 100-109 and an individual whose FSIQ falls within this range is able "*to learn from written materials*" (para. 14).

Each of WISC-IV indexes consists of several subtests with scaled scores ranging from 1 to 19. The average range of scaled scores is 8-12. These subtests are briefly described under their respective indexes in the next few paragraphs.

In the VCI, there are five subtests (see Table 3): three are core, i.e., Similarities (SI), Vocabulary (VO), Comprehension (CO) and two are supplemental, i.e., Information (IN) and Word Reasoning (WR). The three core VCI subtests are conducted for the following respective purposes: (i) SI measures logical thinking, verbal concept formation and verbal abstract reasoning; (ii) VO measures verbal fluency and concept formation, word knowledge, and word usage; and (iii) CO measures commonsense social knowledge, practical judgment in social situations, and level of social maturation as well as the extent of development of moral conscience. For the two supplemental VCI subtests, IN measures general cultural knowledge, long-term memory, and acquired facts, while WR measures verbal abstract reasoning (i.e., analogical and categorical thinking), verbal concept formation and expression. More detailed information about the VCI subtests can be found in WISC-IV Examiner Manual (Wechsler, 2003).

Table 3. Scaled Scores of VCI Subtests

VCI Subtests	Raw Score	Scaled Score	Percentile Rank
SI	7	5	5
VO	16	5	5
CO	21	12	75
[IN]*	10	6	9
[WR]*	7	5	5

** [ ] denotes supplemental subtest*

Having a poor SI and WR scores, this means that EE is very much a "concrete" learner than an "abstract" learner. With poor VO and IN scores, it also indicated that he has poor language skills that could have also affected his general knowledge acquisition. Moreover, it could mean that EE would prefer to read easy books.

In the PRI, there are four subtests (see Table 4): three are core, i.e., Block Design (BD), Picture Concepts (PCn), Matrix Reasoning (MR) and one is supplemental, i.e., Picture Completion (PCm). Briefly described, the three core PRI subtests are conducted for the following respective purposes: (i) BD measures the ability to analyze and synthesize an abstract design and then reproduce that design from colored plastic blocks; (ii) PCn measures categorical, abstract reasoning; and (iii) MR measures visual processing and abstract, spatial perception. The only supplemental subtest PCm measures the ability to recognize familiar items and to identify missing parts. More detailed information about the PRI subtests can be found in WISC-IV Examiner Manual (Wechsler, 2003).

Table 4. Scaled Scores of PRI Subtests

PRI Subtests	Raw Score	Scaled Score	Percentile Rank
BD	43	15	95
PCn	18	12	75
MR	22	12	75
[PCm]*	20	9	37

** [ ] denotes supplemental subtest*

In the WMI, there are three subtests (see Table 5): two are core, i.e., Digit Span (DS) and Letter-Number Sequencing (LNS) and one is supplemental, i.e., Arithmetic (AR). Briefly described, the two core WMI subtests are conducted for the following respective purposes: (i) DS measures short-term auditory memory and attention; and (ii) LNS measures attention span, short-term auditory recall, processing speed and sequencing abilities. The only supplemental subtest AR measures numerical accuracy, reasoning and mental arithmetic ability. More detailed information about the WMI subtests can be found in WISC-IV Examiner Manual (Wechsler, 2003).

Table 5. Scaled Scores of WMI Subtests

WMI Subtests	Raw Score	Scaled Score	Percentile Rank
DS	12	8	25
LNS	6	4	2
[AR]*	21	11	63

** [ ] denotes supplemental subtest*

Finally, in the PSI, there are three subtests (see Table 6): two are core, i.e., Coding (CD) and Symbol Search (SS) and one is supplemental, i.e., Cancellation (CA). Briefly described, the two core PSI subtests are conducted for the following respective purposes: (i) CD measures visual-motor dexterity, associative nonverbal learning, and nonverbal short-term memory; and (ii) SS is a memory-based measure that determines whether a target symbol appears among the symbols shown in a search group. The only supplemental subtest CA measures visual vigilance/neglect, selective attention, and speed in processing visual information. More detailed information about the PSI subtests can be found in WISC-IV Examiner Manual (Wechsler, 2003).

Table 6. Scaled Scores of PSI Subtests

PSI Subtests	Raw Score	Scaled Score	Percentile Rank
CD	38	10	50
SS	26	14	91
[CA]*	103	16	98

** [ ] denotes supplemental subtest*

Interestingly, different psychometric profiles based on the scaled scores of the WISC-IV subtests can be created to identify if EE did manifest learning difficulties and behavioral challenges. Here are five such WISC-IV profiles that played the key role in identifying EE's learning and behavioral issues of concern.

There are two WISC-IV profiles that have been used to identify if a child displays learning difficulties or disabilities (LD). They are the ACID profile (Watkins, Kush, & Glutting, 1997) and the SCAD profile (Kaufman, 1994). The cutoff score for either of the two profiles is 40 (where the mean subtest scaled score is always 10). EE's total score for the ACID profile was 35, i.e., five points below the cutoff score of 40. This indicated that the child might have LD with some challenging behavioral issue. His total score for the SCAD profile was 43, i.e., three points above the cutoff score. This suggested that EE did not have LD. When the two set of profile scores were compared, the preliminary conclusion that could be drawn was that EE might have some behavioral problems that could have been affecting his learning.

There are three WISC-IV profiles that are used to identify if a child displays behavioral problems in terms of (i) distractibility; (ii) poor attention-concentration span; and (iii) impulsivity. They are the ADS profile (previously known as Freedom from Distractibility Index from WISC-III) (Anastopulos, Spisto, & Maher, 1994); ACoDS profile whose focus is on attention-concentration span (Harrier & DeOrnellas, 2005; Riccio, Cohen, Hall, & Ross, 1997) and AIDS profile which concerns about impulsive behavior (Harrier & DeOrnellas, 2005). The cutoff score for ADS profile is 20 since it consists of two subtest scaled scores, while the cutoff score for ACoDS and AIDS profiles is 30. EE's total score for the ADS profile was 19, i.e., one point below the cutoff score of 20, suggesting that the high possibility that distractibility could be an issue for him. His total score for the ACoDS profile was 29, also one point short of the cutoff score of 30, indicating that the presence of poor attention-concentration span. Lastly, EE's total score for the AIDS profile was 25, i.e., five points below the cutoff score of 30, indicating that the child certainly displayed impulsivity.

In summary, from the WISC-IV profiling results, EE did not manifest LD. However, it was quite obvious the child displayed symptoms of ADHD: distractibility, inattention and impulsivity. In other words, the child can be described as having ADHD-Combined subtype (i.e., a combination of ADHD-Inattention subtype and ADHD-Hyperactivity/Impulsivity subtype).

4.2 Mathematics Attitudes & Perceptions Survey-Questionnaire

The Mathematics Attitudes and Perceptions Survey-Questionnaire (MAPS-Q) instrument (Code et al., 2016) was designed to characterize a student's perception of mathematics in an authentic educational setting.

There are seven categories in the MAPS-Q (Code et al., 2016): #1-confidence in, and attitudes towards mathematics (Confidence); #2-persistence in problem solving (Problem Solving); #3-a belief about whether mathematical ability is static or developed (Growth Mindset); #4-motivation and interest in studying mathematics (Interest); #5-views on the applicability of mathematics to everyday life (Real World); #6-learning mathematics for understanding (Sense Making); and #7-the nature of answers to mathematical problems (Answers). Altogether, there are 31 statements and 1 filter statement.

To complete MAPS-Q (Code et al., 2016), a student has to respond to each question using a 5-point Likert format: Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree. The student receives 1 point for a question if their answer is in the same direction, i.e., in the disagree or agree direction, as the expert consensus, given at the end of each question. If the student responds in the opposite direction of the expert consensus, or a neutral response is given, s/he will receive a 0 score for that question. The total expertise index is calculated by averaging the scores for all questions except 19, 22, and 31 (underlined; see Table 7). Subscale scores are calculated analogously. The Total Expertise Index is 29. The higher the index the better is a respondent's attitude and perception toward mathematics learning.

Table 7 shows EE's responses to the MAPS-Q items. His Total Expertise Index is 9, which is within the negative range of scores. This means that EE has a negative mathematics attitude and perception.

Table 7. MAPS-Q Results

Category	Items	Responses	Raw Score	Total Score
Growth Mindset (#3)	5,6,22,31	A, DA, SA, A	0	
Real World (#5)	13,15,21,25	DA, DA, A, A	1	
Confidence (#1)	1,14,17,20	DA, A, A, A	2	
Interest (#4)	12,26,32	DA, A, DA	1	
Persistence (#2)	8,10,24,29	DA, DA, A, A	2	
Sense Making (#6)	3,4,11,18,23	SA, SA, A, A, DA	2	10
Answers (#7)	2,7,9,16,28,30	A, A, A, A, A, DA	1	
No category but scored for expertise	27	A	0	
Filter statement	19	A	1	
Expertise (Expert Consensus)	All except 19,22,31		9	
Descriptor	--	--	Negative	--

Key: SD=Strongly Disagree, DA=Disagree, A=Agree, SA=Strongly Agree

4.3 Test of Mathematical Abilities-2nd Edition

The Test of Mathematical Abilities-2nd Edition (TOMA-2) (Brown, Cronin, & McEntire, 1994) has been developed for use in grades 3 through 12 not only to provide standardized information about two major skill areas - story problems and computation - but also to provide related information about attitude, vocabulary, and general cultural application of information.

The main reason of administering TOMA-2 is because the standardized mathematics measure can be used for five purposes (Brown, Cronin, & McEntire, 1994): "*(a) to identify those students who are significantly below their peers in mathematics and who might profit from supplemental help, (b) to determine particular strengths and weaknesses among mathematics abilities, (c) to document progress that results from special interventions, and (d) to provide professionals who conduct research in the area of mathematics with a technically adequate measure*" (p.3).

There are four core subtests, i.e., Vocabulary (VO), Computation (CO), General Information (GI) and Story Problems (SP), and one supplemental subtest, i.e., Attitude toward Math (AT). Below is a brief description of each subtest:

- Vocabulary (VO): This first subtest assesses an examinee's mathematics vocabulary. According to Brown and McEntire (1984), *"[V]ocabulary is important both as an indicator of cognitive development and as a tool of instruction … involves the meaning-bearing signs of a content area"* (p.2). They emphasized that *"[C]omplex rules govern the relationship of such signs to ideas and to objects, and mastery of vocabulary is taken as indirect evidence for the mastery of these complex relational rules"* ((Brown & McEntire, 1984, p.2). Hence, the mastery of mathematics vocabulary is regarded as indirect evidence that the examinee has understood the complex mathematical concepts.
- Computation (CO): This is the second subtest in TOMA-2 (Brown, Cronin, & McEntire, 1994). *"The mastery of arithmetical computation is the major public goal of most mathematics programs, regardless of any other intentions they may have"* (Brown & McEntire, 1984, p.2). As such, those students with good computational facility rarely have problems in mathematics learning.
- General Information (GI): In this third subtest, an examinee's responses to GI items can provide "*clues about the child's general range of information, alertness to the environment, and even social or cultural background*" (Sattler, 1982, p.171). School experiences and high intellectual interests outside home and school can also provide general knowledge or general information about one's cultural environment. Hence, "a generally rich or impoverished 'map of the world' into which additional mathematics instruction may be seen as helpful or interesting" ((Brown & McEntire, 1984, p.3).
- Story Problems (SP): In this fourth core subtest, *"verbal descriptions of various problem situations that require a solution through some sort of mathematical reasoning and often computation as well"* (Brown & McEntire, 1984, p.3) are provided as story problems. An examinee who struggles to do well in this subtest can provide the barriers, i.e., "reading, syntax (the understanding of grammatical structures), sorting relevant from extraneous information, and basic understandings of mathematical processes," (Brown & McEntire, 1984, p.3) that are affecting him/her to using math to solve problems become apparent in story problems.
- Attitude Toward Math (AT): This is a supplemental subtest. Its result is not used in the computation of Math Quotient (MQ). According to Aiken (1972), *"[T]he term attitude as used in the [research] studies ... means approximately the same thing as enjoyment, interest, and to some extent level of anxiety"* (p.229). There is an assumption that if AT is generally poor, then mathematics performance will also be poor. In fact, a strong causal relationship between attitudes and achievement in mathematics is found in research (Kulm, 1980).

Table 8 below presents EE's results obtained from the TOMA-2 administration at one sitting. In one study involving 38 students with learning disabilities, Brown, Cronin and McEntire (1994) found that the average standard scores of these participating subjects with learning difficulties in mathematics produced the following TOMA pattern: VO=6, CO=6, GI=7, SP=7, and AT=9 (or 66779) (Brown, Cronin, & McEntire, 1994; Brown & McEntire, 1984). "*Because 10 is the score expected of typical students, these low scores indicate that this group of students evidences problems, especially problems involving math performance*" (Brown, Cronin, & McEntire, 1994, p.36). The conclusion was also supported by the unusually low MQ of 79 for this group.

EE's TOMA-2 results (see Table 8) produced the following pattern of VO=6, CO=7, GI=7, SP=8, and AT=5 (or 67785). Among the four core subtests, his VO and GI standard scores agreed with the TOMA pattern. His CO and SP standard scores were one point above the same two core subtests in the TOMA pattern, while his AT standard score was significantly below that of the same supplemental subtest in the TOMA pattern. His MQ was 80 in the below average range which was unlike of the MQ of 79 in the poor range.

Interestingly, EE's poor performance in the VO subtest with a scaled score of 6 is also confirmed and supported by his scaled score of 5 in the VO subtest of the VCI of WISC-IV. This suggests that EE has poor verbal fluency and concept formation, word knowledge, and word usage in his math learning. This agrees with the first struggle in math learning as listed by Rosenfeld (2019) in the three key math learning struggles for children with ADHD. Coupled with his poor WMI results in the WISC-IV administration, EE's standard score of 77 at 6%ile rank made it even more challenging for the child to want to learn math and/or adopt a positive attitude toward math learning.

Table 8. TOMA-2 Results

Subtests	Raw Score	Percentile Rank	Std Score (SS)	Sum of SS	Descriptor	Age Equiv.	Grade Equiv.
Vocabulary	2	63	6	28	Below Ave	8:03-8:09	2.5-3.0
Computation	7	16	7		Below Ave	7:00	1.2
General Information	3	16	7		Below Ave	6:09	1.0
Story Problem	4	25	8		Ave	6:09	1.0
Attitude Toward Math	34	5	5	--	Poor	--	--
Math Quotient		9	80	--	Below Ave	--	--

As a result, it is difficult to describe EE as having MLD and certainly not dyscalculia, which is considered a more severe form of MLD. The findings from this TOMA-2 (Brown, Cronin, & McEntire, 1994) results suggested that EE's poor mathematics performance was more of his poor attitude toward mathematics than suffering from a form of MLD.

5. Conclusion

Results from the diagnostic battery assessment comprising of WISC-IV (Wechsler, 2003), MAPS-Q (Code et al., 2016) and TOMA-2 (Brown, Cronin, & McEntire, 1994) indicated that despite his borderline deficient working memory (see WMI results of WISC-IV) and below average verbal comprehension (see VCI results of WISC-IV), EE did not manifest LD or for that matter, mathematics learning disability (MLD). It was more of his poor attitude toward mathematics (see the AT subtest result of TOMA-2) as well as negative perception of mathematics learning (see the MAPS-Q results). EE's TOMA-2 pattern of 67785 based on the scaled scores of the following subtests – VO=6, CO=7, GI=7, SP=8, and AT=5 – failed to match the TOMA-2 pattern of 66779 for mathematics learning disability (MLD) (Brown & McEntire, 1984) (Brown, Cronin, & McEntire, 1994). His Total Expertise Index for MAPS-Q was 9, which fell within the negative range of scores, confirming EE's negative mathematics attitude and perception.

However, according to Kennedy (2019), "*MLD is an umbrella term used when a person has more trouble learning math than would be predicted by other factors*" (para.4). The Diagnostic and Statistical Manual of Mental Disorders-5th Edition (DSM-5) (American Psychiatric Association, 2013) has defined MLD as a specific learning disorder with impairment in mathematics in which an individual shows deficits in one or more of the following areas: "*number sense, memorization of arithmetic facts, accurate fluent calculation, and/or accurate math reasoning*" (also see Kennedy, 2019, para.4). Technically speaking, EE's purported learning difficulty in mathematics (be it due to poor attitude toward mathematics learning and/or negative mathematics attitude and perception) falls within this inclusive definition of MLD. It must not be forgotten that having mathematics anxiety can also lead to MLD (Kennedy, 2019).

According to the nosological system of MLDs and its subtypes proposed by Newman (1998, 1999), EE's MLD could be identified under the subtype of Category C Pseudo-Dyscalculia in the sub-category C.1.b.D Pseudo-Dyscalculia with learned mathematics avoidance (see p.22) [33].

In addition, it is quite obvious that EE also displayed symptoms of ADHD: distractibility (see the ADS profile of WISC-IV), inattention (see the ACoDS profile of WISC-IV) and impulsivity (see the AIDS profile of WISC-IV). In other words, the child can be described as having ADHD-Combined subtype (i.e., a combination of ADHD-Inattention subtype and ADHD-Hyperactivity/Impulsivity subtype). According to Kennedy (2019), "*[N]early a third of children with ADHD also have a math learning disability*" (para.1). However, although EE's TOMA-2 pattern of 67785 did not quite match the original TOMA pattern of 66779, under the inclusive definition of MLD, it is identified as pseudo-dyscalculia with learned mathematics avoidance.

To better understand EE's MLD condition and its connection to ADHD, Kennedy (2019) argued that "*it is helpful to look at the two types of cognitive processes involved in doing math*" (para.5): (i) domain-general processes, and (ii) domain-specific processes. The former refers to the basic processes of the brain that involve in working memory, processing speed, executive functioning, and language processing responsible for most of the overlap with other LDs. The latter refers to specific processes involve in solving story problems in mathematics using the brain's hard wiring, known as the Number Module, that is located in the parietal lobe. The Number Module "*is responsible for detecting, comparing, and manipulating the numerosity parameter, where the brain subitizes, or automatically recognizes a small amount without counting, compares amounts, and orders* *amounts from least to greatest*" (Kennedy, 2019, para.8). Hence, these domain-specific processes affect mathematics learning and are also responsible for MLDs.

As mentioned earlier, EE was assessed to have borderline deficiency in his working memory (WM) with a standard score of 77 for his WMI. Limited WM can cause two areas of math difficulty: (i) memorization of mathematical facts; and (ii) ability to follow procedures. As such, EE with borderline functioning WM needs explicit instruction with manipulatives to demonstrate how to execute mathematical operations or solve story problems (as confirmed by his poor SI and WR subtest scores) from his teachers in order to understand and memorize the steps he needs in his problem solving. "*The more neural pathways a brain has to access information, the more efficiently and accurately it does so. That said, rote memorization should be accompanied with manipulatives and models, as long as they are immediately and explicitly connected to the facts*" (Kennedy, 2019, para.11).

With below average VCI with a standard score of 85, EE would have difficulty in language processing to initiate and maintain robust connections within and between the worlds of real quantities, language of mathematics, and written symbols. This problem can lead to slower processing and less accurate retrieving of facts from semantics-based, long-term memory. Hence, EE needs mathematical concepts, procedures and facts to be explicitly, consistently and repeatedly linked. He also needs a lot more practice to get automatic. This constitutes the main underlying challenge in EE's math learning and, in turn, the findings agree with the three key struggles in math learning as postulated by Rosenfeld (2019).

Finally, there is still much to be done for EE's case, especially in carrying a full cross-battery assessment (X-BA) rather than just administering a diagnostic battery assessment (DBA). The obvious reason is that DBA has its own limitations in accurate identification and confirmation of EE's behavioral and/or learning challenges, i.e., attention deficit/hyperactivity disorder-combined subtype and pseudo-dyscalculia with learned mathematics avoidance. As a result, it requires an assessor to be (i) experienced in assessing and working with children with ADHD and MLD, (ii) widely read and up-to-date in both content knowledge so that he/she can infer from the findings to pinpoint the diagnosis, and (iii) treatment strategies, in order to be an effective educational diagnostician and therapist.

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