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Characteristics of Dyscalculia in Mathematics Learning

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Abstract

Understanding dyscalculia is crucial in helping pupils to achieve, especially in mathematics learning. However, the researches in dyscalculia is still yet new and few. The purpose of this paper is to discuss about the characteristics of dyscalculia in mathematics learning. In this paper, the authors will discuss about characteristics of dyscalculia categorised in the four domains. These characteristics are listed based on the study of previous literature reviews. These four domains are: (a) number sense; (b) working memory; (c) accurate or fluent calculation; and (d) mathematics reasoning. The implication of this paper is it is able to act as guidance for teachers and parents in detecting the children with symptoms or characteristics of dyscalculia in the normal classrooms.

Keywords: Dyscalculia; Special Education; Learning Disabilities; Number Sense; Mathematics Reasoning

INTRODUCTION

There are six categories of special needs pupils, which include pupils with; (1) visual impairment; (2) hearing impairment; (3) speech difficulties; (4) physical disabilities; (5) multiple disabilities; and (6) learning disabilities (Ministry of Education Malaysia, 2013). Dyscalculia is a learning disability in mathematics. Hence, it is under the sixth category, namely learning disabilities.

The variation in criteria used across studies makes it difficult to identify the central characteristics of a dyscalculic pupil (Lewis & Fisher, 2016). Although the normal children might sometimes face difficulties in mathematics, however dyscalculic pupils endure a lot more struggles than other pupils in the same age. In this paper, the researchers will discuss about four domains and twenty characteristics of dyscalculia in mathematics learning.

SPECIAL EDUCATION

Dealing with learning disability pupils is indeed a challenging experience for most special education teachers (Noor Aini Ahmad, 2018). A special education teacher predicted a higher knowledge of intervention strategies in dyscalculia if compared with a mainstream teacher (Sousa, Dias, & Cadime, 2016). Special education pupils may require an unusually high level of supervision and time-consuming interface with medical, educational, and mental health personnel. Some of the special education pupils function significantly below their developmental age (Pickar & Kaufman, 2015).

Special education pupils learn at a relatively slow pace, they might need much time to build a basis of mathematics facts before they can proceed with more advanced levels of knowledge (Bakker, van den Heuvel-Panhuizen, & Robitzsch, 2016). Teachers need to play a key role to an early detection of the different learning needs (Abu-Hamour & Al-Hmouz, 2016).

As a summary, special education is an education specially designs for the pupils who have special educational needs. Teachers need to be very patient because the pupils in special education are often considerably behind in their learning ability, as compared with their same-aged peers in general education. Hence, special education teachers need to pay more attention to the pupils with different learning abilities, especially dyscalculic pupils who faced learning disability in mathematics learning.

LEARNING DISABILITIES

Each child has a unique individual profile, character, abilities, and difficulties (Noor Aini Ahmad, 2019). Learning disabilities in children with brain mapping show one or several of the following cues: sharp and focal slow waves in one or more brain regions such as the occipital lobe, wernike area, Broca area and sensory-motor area (Hashemian & Hashemian, 2015). Education at primary school level becomes a burden when there are problems in learning by children. Learning becomes difficult and painful when children are having reading, writing and mathematical learning disabilities due to cognitive deficit (Radhika & Kiran, 2017).

Pupils with learning disabilities should be given the chance to learn according to their needs and abilities (Yahya, Noor Aini Ahmad, & Yoong, 2019). There are many factors of learning disability, such as impaired concentration, memory, dyslexia, dyscalculia, and the environment (Munir, Rasim, Chayadi, & Riza, 2016). Three kinds of learning disability are writing disability, reading disability, and mathematical disability (Rajivsureshkumar, Malarvizhi, & Deebanchakkarawarthi, 2019). Pupils will learning disabilities should be given assistance to achieve their goal (Noor Aini Ahmad & Yoong, 2018).

In short, learning disability is affected by many factors, especially environmental factor. Some categories of learning disabilities are dyslexia, dyscalculia, and dysgraphia. Pupils with learning disability face difficulties when comes to learning because they are much slower than their peers in the same chronological age. Thus, learning disability among pupils with dyscalculic should be detected in order to help them to improve in their mathematics learning.

DYSCALCULIA

The ICD-10 Classification of Mental and Behavioral Disorders defined dyscalculia as a specific disorder that encompasses deprived mathematical skills in an individual (World Health Organisation, 2013). Dyscalculia is a learning disability in mathematics. It is also known as number dyslexia (Yoong & Noor Aini Ahmad, 2020). Some define dyscalculia in functional terms, involving specific and severe mathematical difficulties, while others treat it as a neuro-cognitive disorder, involving underdevelopment of the areas of the brain performance on an assessment is in the bottom five percent relative to a population (Finesilver & Rodd, 2017). Dyscalculia is one type of learning disabilities. It has to be detected as early as possible.

There are different types of dyscalculic pupils based on their disabilities in Mathematics learning, such as developmental dyscalculia, disabilities in mathematical concepts, difficulties in specific arithmetic operations, disabilities in learning arithmetic, and acalculia (Miundy, Zaman, Nordin, & Ng, 2019). Table 1 shows the types of dyscalculia with their explanation.

Table 1: Types of Dyscalculia. Adapted from Miundy, Zaman, & Ng, 2019

Types of Dyscalculia	Explanation
Verbal Dyscalculia, Aphasia Dyscalculia	Inability to understand numbers.
Lexical Dyscalculia, Alexic Acalculia	Does not possess literacy in mathematics symbols.
Graphical Dyscalculia, Agraphic Acalculia	Inability to write mathematics symbols.
Operational Dyscalculia, Frontal Acalculia	Inability to conduct mathematics operations and calculations.
Ideognostic Dyscalculia, Anarithmetia	Inability to understand mathematical concepts or do mental arithmetic.
Practognostic Dyscalculia, Spatial Acalculia	Inability to make enumeration, manipulation, comparison, or relation between objects and numbers.

At present, there is very little agreement about what causes dyscalculia. Research into dyscalculia is at an early stage, but some researchers believe that it is caused by the way the brain is structured (Emerson & Babtie, 2013). Recent research suggests that dyscalculia can also occur developmentally, as a genetically linked learning disability which affects a person's ability to understand, remember or manipulate numbers or number facts (Cotton, 2013). There are still very few studies explore about the causes of dyscalculia, however previous researches showed that dyscalculia related to brain structure, genetic and environmental factors.

The prevalence of specific learning disorder across the academic domains of reading, writing, and mathematics is five percent to fifteen percent among school-age children across different languages and cultures. Prevalence in adults is unknown but appears to be approximately four percent (American Psychiatric Association, 2013). There are four to six percent of the pupils among the population are dyscalculic (Bird, 2017). The presence of dyscalculia may affect mathematics performance among normal students. This learning disability in mathematics occurs among individuals across the whole IQ range. The estimated prevalence of dyscalculia range is between 3% and 6% of the population. In Sabah, the researchers found out that 5.5% of the primary school pupilsare suffering from dyscalculia (Chin, Pang, Wong, Tan, & Lee, 2014). In another words, there will be one dyscalculia out of twenty pupils in our classes. Thus, the characteristics of dyscalculia in mathematics learning should be identified to detect the dyscalculic pupils in our normal classrooms.

However, a child with dyscalculia is a hundred times less likely to receive an official diagnosis of that disorder than a child with dyslexia. It is necessary for them to obtain the specialist educational support (Morsanyi, van Bers, Mccormack, & McGourty, 2018). This shows that even though the prevalence of dyscalculia almost the same as dyslexia, but the researches on dyscalculia is very less and hence it is crucial and much needed.

CHARACTERISTICS OF DYSCALCULIA

Dyscalculia has become a more familiar term in recent years. However, there is still widespread debate about the nature of the disorder and various different definitions are in use (Finesilver & Rodd, 2017). Most of the teachers do not have sufficient knowledge on characteristics, symptoms, and intervention strategies for dyscalculia (Sousa, Dias, & Cadime, 2016). Dyscalculic pupils show disinterest in mathematics. It is difficult for them to decide which arithmetic operation to apply, either divide, multiply, add or subtract. They also show difficulty to decide which side is left and which is right. Little issues that we have to deal in our daily lives and make an enormous impact in the individual, socially and personally. Thus, they might develop a math phobia (Ferraz & Neves, 2015).

Learners with dyscalculia are known to have a delay in their general mathematics achievement level (Hoof, Verschaffel, Ghesquiere, & Dooren, 2017). Some characteristics of dyscalculia are inability to subitize, difficulty in memorizing and remembering number facts, unable to solve simple

arithmetic operations, and do not know whether the answer they have obtained is correct or wrong (Yoong, 2020). Dyscalculic pupils have more difficulty in acquiring numbers, number words, calculations, and other number related concepts (Olkun, Altun, Sahin, & Denizli, 2015).

According to Diagnostic and Statistical Manual of Mental Disorder (DSM-5), dyscalculia is a specific learning disorder with impairment in mathematics in the aspects of number sense, memorization of arithmetic facts, accurate or fluent calculation, and accurate math reasoning (American Psychiatric Association, 2013). In short, a dyscalculic pupil poses some disabilities or difficulties in mathematics learning if compare with their peers in the same age. Thus in this paper, the researcher will discuss the characteristics of dyscalculia based on four domains, namely; (1) number sense; (2) working memory; (3) accurate of fluent calculation; and (4) mathematics reasoning.

Number Sense

Number sense is a spontaneous ability to process approximate number (Hannagan, Nieder, Viswanathan, & Dehaene, 2017). Number sense involved in subitizing, approximate calculation, comparison, bisection, and computations, such as subtraction, which cannot be solved based on knowledge of basic math facts (Karakonstantaki, Simos, Michalis, & Micheloyannis, 2017). It is found to be a core numerical ability for children in learning early mathematics (Chinn & Ashcroft, 2016). Number sense plays an important role as it is related to mathematical performance and can explain the difficulties some children have with learning mathematics. The children with a weakness in number sense will have lower mathematical ability than children without such a weakness. It can be measured with three tasks: dot comparison, number comparison, and number line 1-100 (Kroesbergen & van Dijk, 2015).

Overall, number sense is a natural ability born in every people. It is the foundation for everyone to learn the numeracy such as numbers and arithmetic skills. Dyscalculic pupils have a low number sense which makes them to have a low mathematical ability compared to their peers. Thus, number sense can be one of the important indicators to detect pupils with learning disability of dyscalculia.

Working Memory

Working memory for serial order may be a critical component to investigate when exploring short-term storage capacities in developmental dyscalculia (Attout & Majerus, 2015). A poor working memory is at the heart of dyscalculia. This makes it harder to memorize math facts and apply them to a math problem (Alloway & Alloway, 2015). Some pupils were not able to memorize multiplication facts due to the different level of working memory (Yoong & Noor Aini Ahmad, 2018).

Pupils do not learn effectively when their limited working memory is directed to unnecessary or redundant information (Centre for Education Statistics and Evaluation, 2017). In a nutshell, working memory is a limited capacity that is responsible or temporarily holding of information. Short-term memory and long-term memory are one of the predictors of dyscalculia. Pupils with impairments in working memory are having impairment in mathematical ability. Hence, limited working memory can be an indicator for detecting dyscalculic pupils.

Accurate of Fluent Calculation

Calculation is the foundation of word problems. Problems of calculation are affected by difficulties in numerical operations vocabulary and procedural knowledge (Peng & Lin, 2019). A large literature demonstrates the roles and contributions of calculation accuracy and calculation fluency in variety of mathematics outcomes (Fuchs et al., 2016). Both calculation accuracy and calculation fluency by the early primary grades can be used to predict later mathematics achievement (Rittle-Johnson, Fyfe, Hofer, &Farran, 2016).

In short, calculation includes the four basic arithmetic operations, namely addition, subtraction, multiplication, and division. Accurate calculation means the ability of the pupil to solve the arithmetic operations correctly without mistakes, whereas fluent calculation means the ability of the pupil to solve the arithmetic operations effortless without hesitate for long to interpret each and every single procedure. Thus, inability to do calculation accurately or fluently can be another indicator for detecting dyscalculic pupils.

Mathematics Reasoning

Mathematics is rich enough to permit multiple pathways to produce valid mathematical reasoning (Goldstone, Marghetis, Weitnauer, Ottmar, & Landy, 2017). Mathematics reasoning is a process of communication with others or with oneself that allows for inferring mathematical utterances from other mathematical utterances (Jeannotte & Kieran, 2017). Accordingly, the ability of mathematics reasoning includes formulating questions, solving strategies, and justifying them (Mata-Pereira & da Ponte, 2017). In this study, the meaning of mathematic reasoning is an ability to understand mathematics questions, solve problems, and judge whether an answer is correct or wrong by giving reasonable justification.

DISCUSSION

Based on the literature review, the researcher has summarized 20 characteristics of dyscalculia based on the four domains as stated. The characteristics of dyscalculia in the domain of number sense are subitizing, sequencing, counting backwards, recognising numbers, and poor skills with money (Alloway & Alloway, 2015; Chinn, 2016; Laurillard, 2016; Bird, 2017). Furthermore, the characteristics of dyscalculia under the domain of working memory are short-term memory, long-term memory, gets lost in multi-step word problem, struggle with mental arithmetic, struggle with multiplication facts, and forgets mathematical procedures (Alloway & Alloway, 2015; Chinn, 2016; Bird, 2017).

Subsequently, the characteristics of dyscalculia under the domain of accurate or fluent calculation are trouble in learning to count, slow processing speed, count on for addition facts, difficult to count sequences, use tally marks for addition or subtraction (Alloway & Alloway, 2015; Chinn, 2016; Bird, 2017). Last but not least, the characteristics of dyscalculia under the domain of mathematics reasoning are estimating, difficulty in progressing, difficulty in judging, use formulas without understanding (Chinn, 2016), and so on. Table 2 shows the characteristics of dyscalculia.

Table 2: Characteristics of Dyscalculia

Domain	Characteristics of Dyscalculia
1. Number Sense	• Subitizing • Sequencing • Counting Backwards • Recognising Numbers • Poor skills with money
2. Working Memory	• Short-term Memory • Long-term Memory • Gets lost in multi-step word problem • Struggle with mental arithmetic • Struggle with multiplication facts • Forgets mathematical procedures
3. Accurate or Fluent Calculation	• Trouble in learning to count • Slow processing speeds • Counts on for addition facts • Difficult to count sequences • Use tally marks for addition or subtraction
4. Mathematics Reasoning	• Estimating • Difficulty in progressing • Difficulty in judging • Use formulas without understanding

CONCLUSION

Generally, dyscalculic pupils are able to achieve in their learning if they are being detected as earlier as possible. This paper had discussed about the characteristics of dyscalculia based on four domains, namely; (1) number sense; (2) working memory; (3) accurate or fluent calculation; and (4) mathematics reasoning. The characteristics of dyscalculia in mathematics learning that had been listed in this study are able to become the guidance for teachers and parents to detect whether their pupil or child are at-risk for dyscalculia. These pupils are suggested to go through the screening test carried by paediatrician or clinical psychologist in hospital. Hence, proper intervention or diagnosis should be carried out on dyscalculic pupils in order to improve their mathematics learning in different aspects, such as number sense, working memory, accurate or fluent calculation, and mathematics reasoning.

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