

Enhancing the Basic Mathematical Skills of Pupils with Mathematical Learning Difficulties using Metic Board: A Conceptual Framework

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Abstract: In the Malaysian education system, mathematics is a compulsory subject for students. However, it is often perceived as difficult to master by many students, as evidenced by analyses showing weaker performance in mathematics compared to other subjects. Previous research has identified that one of the primary challenges in mastering mathematics is the lack of basic mathematical skills among students from the early stages of schooling, which subsequently leads to difficulties in learning arithmetic skills. Therefore, this article presents recommendations for enhancing basic mathematical skills for students with learning difficulties in mathematics, emphasizing the importance of planned interventions and the effectiveness of developing a learning tool called the 'Metic Board'. This tool is designed based on Piaget's Cognitive Development Theory, Dehaene's Triple-code Model, and Wong's Framework, aiming to assist more children struggling with mathematics, particularly in foundational skills such as number sense, addition, subtraction, multiplication, and division. This article illustrates that students who are weak in mathematics, particularly those with learning difficulties, require not only systematic interventions but also learning tools that are appropriate for their cognitive development level and sensory development, which influence their ability to learn mathematical skills.

Keyword: Arithmetic, Intervention, Learning Difficulties, Mathematics, Number Sense, Specific Learning Disorder.

INTRODUCTION

Basic mathematical skills, including number sense, addition, subtraction, multiplication, and division, are crucial for pupils' academic success and daily life. These skills form the foundation for more advanced mathematical concepts and problem-solving abilities, influencing educational and career opportunities (Corso, et al., 2024). However, progress towards quality education has been slower than required, with the Sustainable Development Goals Report 2023 indicating that an estimated 300 million pupils will lack essential numeracy and literacy skills by 2030 (United Nations, 2023). The 2022 report also highlighted a crisis in learning, with many children struggling with fundamental numeracy (United Nations, 2022).

The COVID-19 pandemic exacerbated these issues, with prolonged school closures affecting educational outcomes. In the long term, increased absenteeism is expected to worsen retention and graduation rates, particularly among disadvantaged pupils, including those from poor families and those with learning or physical disabilities (United Nations, 2020). Teachers and pupils with special educational needs have faced additional challenges in distance learning, further hindering educational progress (Maurer et al., 2021).

Given these challenges, it is imperative to develop and implement effective interventions to support pupils with mathematics learning difficulties. This review explores various strategies and tools, such as the Metic Board and a series of educational books, designed to enhance basic mathematical skills systematically. By understanding and addressing the cognitive development of pupils, educators can plan more effective learning activities, ultimately improving educational outcomes for all students.

Background of Study

In year 2023, there is a total of 97,494 pupils with learning disabilities in our country (Ministry of Education Malaysia, 2023). Malaysian pupils lag behind aspirational peers in mathematics as measured by international assessments (World Bank Group, 2024). In mathematics, the decline in performance was pronounced in several countries included Malaysia (OECD, 2023). The low performance in mathematics might be contributed by the difficulties faced by pupils when learning this subject.

Dyscalculia is a specific learning difficulty that significantly impacts a child's ability to understand and perform mathematical tasks. At the primary education level, children with dyscalculia often struggle with basic number sense, counting, and understanding numerical relationships. These foundational issues can make it difficult for them to grasp arithmetic facts and perform calculations, leading to challenges in following mathematical procedures and solving multi-step problems (Hornigold, 2023). The main issue is that most teachers have limited strategies to support primary pupils with mathematical learning difficulties (Chin & Fu, 2021). Proper teaching and learning strategies and techniques are needed in order to support primary pupils who are facing difficulties in learning mathematics (Yoong, 2023). Frequent practice, review, and scaffolded instruction are essential strategies to help students retain and build upon their math skills.

The existing tools in teaching basic mathematics skills for pupils with mathematical learning difficulties included abacus course from China (Lu, Ma, Chen, & Zhou, 2020), computerized apple-collecting game from China (Cheng et al., 2019), visual based augmented reality learning application (V-ARA-Dculia) from Malaysia (Miundy et al., 2019), a mobile application named Calculic Kids from Malaysia (Ariffin et al., 2018), a computer play pedagogy intervention from Malaysia (Syah et al., 2015), and a multimedia courseware named DycalCo from Malaysia (Anuar, 2011). However, there was no systematic learning tool that begin with the practice of number sense as the bridge before the children start learning four basic arithmetic skills.

In this study, Metic Board was designed to improve the number sense and basic arithmetic skills among pupils with dyscalculia symptoms. The uniqueness of this Metic Board compared to the existing sources used in schools included it is easy to bring, easy to use, safety, dyslexic-friendly fonts, good quality as it is made of acrylic sheets, and good marketing value Children can bring this Metic Board to anywhere and can learn basic mathematical skills at anytime.

It is a specialized learning tool design to be used together with the book series, entitled Basic Metic. The book series consist of five books, including Book 1 Number Sense, Book 2 Addition, Book 3 Subtraction, Book 4 Multiplication, and Book 5 Division. Metic Board aims to help primary level pupils in mastering abstract mathematical concepts by using tangible and visual materials. Additionally, this learning tool enables teachers and parents to conduct learning activities anywhere and anytime. Thus, the purpose of this article is to design a framework to enhance mathematical skills with Metic Board among pupils with dyscalculia symptoms.

LITERATURE REVIEW

Data of Special Education shows that there are six categories of learning disability in Malaysia, namely specific learning disorders, intellectual disability, autism, ADHD, down syndrome, and others. In this matter, the category of specific learning disorders includes of dyslexia, dyscalculia, and dysgraphia (Ministry of Education Malaysia, 2023). The Diagnostic and Statistical Manual of Mental Disorders (DSM-V) defines dyscalculia as a distinct learning deficit characterised by difficulties in processing numerical information, learning arithmetic facts, and performing calculations (American Psychiatric Association, 2013). Dyscalculia is another term refers to mathematics learning difficulties (Chinn, 2020).

Pupils with specific learning difficulties should be given suitable interventions or activities in accordance with their level of cognitive development (Yoong, 2023). Learning tools, fun activities and a variety of teaching methods should be applied by teachers who are teaching children with specific learning disorder (Ahmad et al., 2022). Most students with mathematics learning difficulties are yet to be identified among the population, and this leads to a lack of suitable interventions that could enhance the level of learning in this group of students (Yoong et al., 2023).

Number sense is natural ability born in every people. It is the foundation for everyone to learn the numeracy such as numbers and arithmetic skills (Yoong & Ahmad, 2021). This intuitive ability differs from the formal number skills learned in or out of school. It is useful for school psychologists and other practitioners to recognize that each of these distinct numerical skills contribute to students' mathematics learning difficulties (Alfonso & Flanagan, 2018). They acted as the foundation for the pupils with mathematics learning difficulties to build knowledge on the basic arithmetic skills (Yoong et al., 2023). Hence, it is very crucial interventions on number sense for pupils with mathematics learning difficulties.

It is important to teach basic arithmetic skills to pupils, especially those who has mathematics learning difficulties (Soltani & Mirhosseini, 2019). The knowledge of arithmetic is a key element in vocational and educational success (Nazari et al., 2022). Pupils with mathematics learning difficulties had poorer arithmetic skills if compared with typical pupils in both formal and informal settings (Vigna et al., 2022). It is a learning difficulty experienced by pupils, such as difficulty in understanding basic mathematical concepts of four operation skills (Pudjoatmodjo et al., 2022). In this study, four basic arithmetic skills refer to addition, subtraction, multiplication, and division.

CONCEPTUAL FRAMEWORK

The underpinned theories in this study are Piaget's Cognitive Development Theory, Dehaene's Triple-code Model, and Wong's Framework for Diagnosing Dyscalculia. According to Jean Piaget, there are four stages of cognitive development, namely; (1) sensorimotor; (2) preoperational; (3) concrete operational; and (4) formal operations. For Piaget, concept of number or numerosity, is built on more basic and more general capacities available initially in the concrete operational stage (Butterworth, 2019). Different characteristics of the stages of growth are important because they explain the association between the pupils' mental processes evolutions and their progression from the cradle to adulthood (Aljojo et al., 2018). If the pupil has trouble in progressing from the material and image, for example, blocks, counters, tallies, to the numbers or symbols, he or she probably has a difficulty or problem with cognitive development. In other words, this pupil remained in the concrete operational stage of Piaget's developmental stages. He or she could also be relying too much on the materials (Chinn, 2020).

Piaget's Cognitive Development Theory mentioned that learning needs to learn through a structured and concrete way as the process of managing information and knowledge in our brain's cognitive structures takes place using the existing schemas (Parthiban et al., 2022). In this study, more emphasize was put on concrete operational stage. This is because the targets pupils for Metic Board are the pupils with mathematics learning difficulties in primary level. They are slow in learning mathematics compare with their peers. Hence, more concrete and visual materials should be utilised when the teaching and learning of basic mathematical skills for these pupils.

Triple-code Model (Dehaene, 1992) consists of three types of different codes, which are analogue magnitude representations, visual Arabic number form, and auditory verbal word frame. [Analogue magnitude representation] refers to the abilities of number comparison and estimation; [visual Arabic number form] refers to the Arabic numeral reading and writing; whereas [verbal word frame] attributed to the abilities of counting, arithmetic fact retrieval, and the use of counting procedures in addition and subtraction (von Aster, 2000). The scopes of Metic Board and Basic Metic included number sense and four basic mathematical skills. Some of the elements within this model are subitizing, estimating, comparison, approximation, calculation, parity, counting, addition, and so on. Hence, these elements were considered when designing the techniques in Metic Board and Basic Metic book series.

Additionally, Framework for Diagnosing Dyscalculia (Wong et al., 2020) shows that perceptions on objects and actions on objects are two main supporting parts towards basic arithmetic skills. Meanwhile, the elements such as simple reaction time, short term-memory, number sense, dot enumeration, number comparison, and arithmetic are also interconnected as shown in this framework. Thus, the elements of this framework were used to design the activities in this study. On the other hand, ADDIE approach was the development model used to design and develop the learning tool of Metic Board and the Basic Metic book series. Fig. 2 shows the conceptual framework of this study.

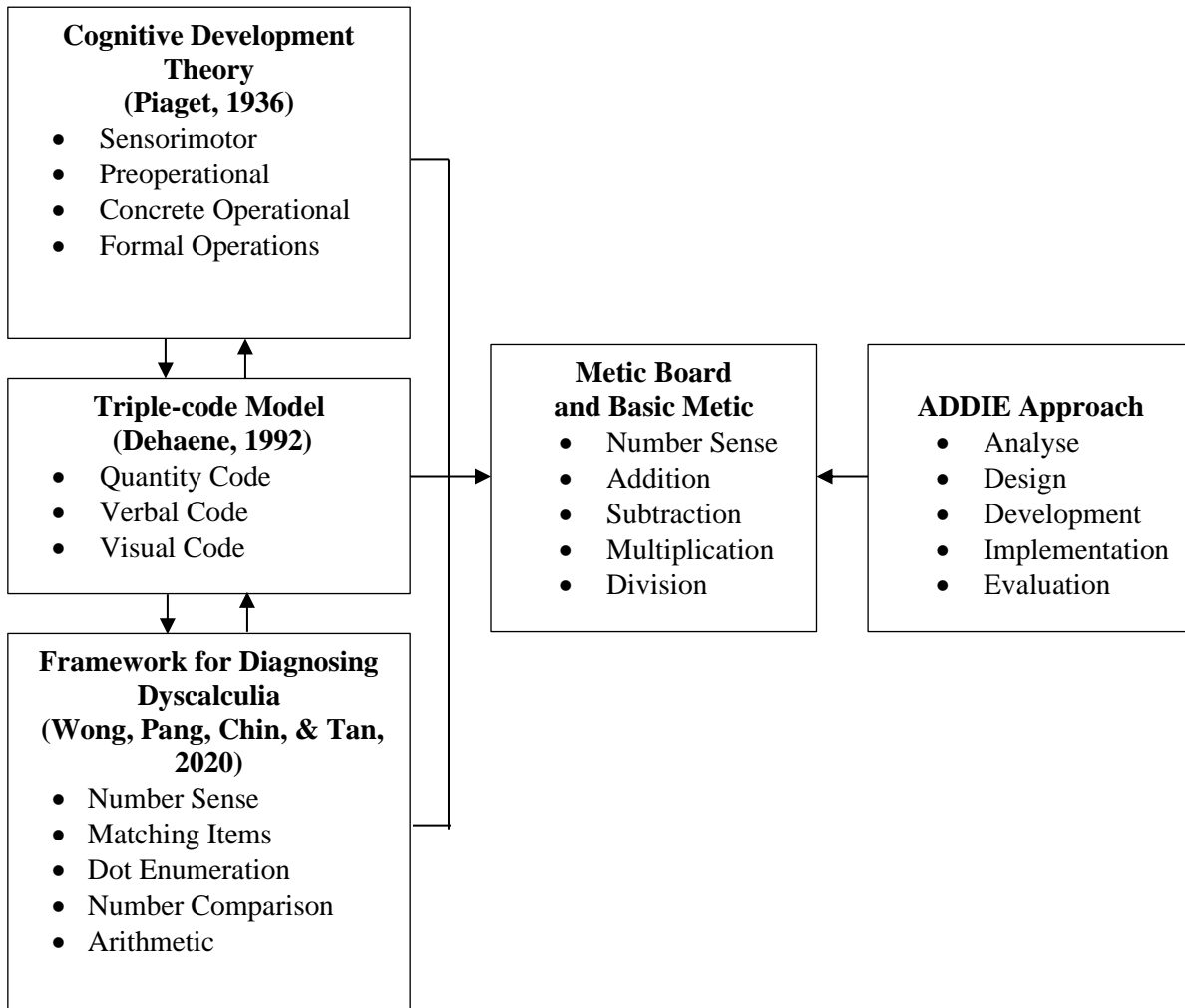


Fig. 2: Conceptual Framework

The main purposes of the Metic Board and Basic Metic are; (1) to assist children in mastering mathematical skills, including subitising, estimating, counting; (2) to help children in understanding quantities, basic colours, and basic shapes; (3) to create a learning resource that aligns with pupils' cognitive development level; (4) to support teachers and parents in conducting learning activities anytime and anywhere; (5) to provide hands-on activities that stimulate pupils' thinking and reasoning skills; (6) to offer a learning material that allows pupils to learn through play; (7) to strengthen children's basic arithmetic skills, specifically addition, subtraction, multiplication, division; and (8) to help pupils in understanding abstract mathematical concepts through concrete and visual materials, such as dots and shapes.

CONCLUSION

Pupils with mathematics learning difficulties should be given equal opportunity to learn mathematics. Number sense and arithmetic skills are important for every individual hence interventions and innovation products need to be developed to help these pupils. A friendly, creative, and inclusive environment with the acceptance of the school society are the crucial elements to assist the pupils with special educational needs.

In this study, a framework to enhance mathematical skills with Metic Board among pupils with dyscalculia symptoms was designed. Teachers can apply this learning tool together with Basic Metic book series according to their pupils' abilities. Other than teachers, parents can also play the role to enhance mathematical skills of their children by implementing the learning activities in Metic Board and Basic Metic book series. This study is not only bringing benefits to the learning of pupils with mathematics learning difficulties, but also the low achievers and those who struggle in learning arithmetic.

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