

## EARLY NUMERACY CHALLENGES AND INTERVENTIONS FOR STUDENTS WITH DOWN SYNDROME: A SCOPING REVIEW

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### ABSTRACT

Numeracy refers to the ability to solve basic mathematical operations, understand simple mathematical ideas, and apply mathematical knowledge and skills in daily life. Most special education students, especially those with Down syndrome, have difficulty mastering numeracy. There are various interventions that have been discussed by researchers around the world to address the problem of the level of numeracy comprehension of special education students. Therefore, this article focuses on the challenges and interventions involved in numeracy for special education students, especially those with Down syndrome. This study uses the scoping review method to obtain data based on challenges and interventions in numeracy. A total of six databases are used to search for articles according to the keywords that have been set. As a result of searching for these keywords, a total of 1771 articles were obtained. However, after the PRISMA screening process was implemented, only 44 articles were selected and coincided with the title of the study. Most articles show that Down syndrome students have difficulty understanding numeracy due to short-term memory. The teachers may be one of the factors that hinder students' understanding of numeracy because of their lack of expertise. Thus, teachers need to use students' existing knowledge or apply elements of daily life to give students an understanding of numeracy. Overall, the level of numeracy comprehension of special education students can be improved with the use of appropriate interventions. The study of numeracy comprehension in special education students needs to be increased, especially in Malaysia.

**Keywords:** Numeracy, challenges, interventions, students with down syndrome, scoping review

### INTRODUCTION

Numeracy is the competence in performing basic operations of mathematics and the ability to apply that knowledge in real-life contexts (Ministry of Education, 2010). According to Siti Rahaimah (2014), numeracy is the basis for continuing the learning of mathematics at higher levels. In addition, numeracy is also more towards the ability to apply mathematical knowledge and skills in problem-solving (Asiahwati, 2015; Geary, 2011; Geiger et al., 2013; Jordan et al., 2009; Sarama & Clements, 2008). The importance of numeracy should be noted in the early stages of learning, especially the basic skills children require in mathematics (Siti Rahaimah, 2014).

In 2012, Jimenez et al. developed a conceptual model of early numeracy teaching and supported it with evidence-based practices for students with low functional special needs. There are four components in the conceptual model for teaching mathematics, namely: (a) targeting early numeracy skills (Sarama & Clements, 2008); (b) using explicit systematic encouragement and feedback (Browder et al., 2008; Spooner, Knight, Browder, & Smith, 2012); (c) the use of stories in daily instruction (Browder, Jimenez, & Trela, 2012); and (d) promoting content generalization through concrete manipulative skills (King, Lemons, & Davidson, 2016; Spooner, Root, Saunders, & Browder, 2019)

and embedded instruction (Jimenez et al, 2012; Othman et al., 2022). According to Jimenez et al. (2012), developing learning in an early numeracy curriculum requires teachers to teach explicitly using concrete manipulatives, systematic encouragement, and clear feedback.

According to Grindle et al. (2020), students with learning disabilities may encounter various challenges leading to poor performance in mathematics. Firstly, they may not be given enough learning opportunities, which can hinder their ability to grasp mathematical concepts effectively (Yoong et al., 2022). Secondly, there may be a focus on teaching functional mathematical skills, such as those required for daily activities like buying items at the store, at the expense of broader instruction, and structured mathematical abilities. Additionally, teachers may feel unprepared or confident in teaching mathematics to students with learning disabilities, which can impact the quality of education they receive. Furthermore, teachers may find it difficult to teach maths due to students' behaviour, challenges, or indifference during lessons, making it challenging to maintain an optimal learning environment. Lastly, teachers may struggle to gather information during daily practice and use evidence-based teaching strategies, which are crucial for facilitating effective learning experiences for students with learning disabilities in mathematics.

Among those with learning disabilities, those with Down syndrome have more difficulties with numeracy (Viorel Agheanaa & Nicoleta Duta, 2015). Down syndrome is caused by an extra copy of chromosome 21, and it is the most common cause of intellectual disability. The IQ of individuals with Down syndrome generally ranges between 25 and 70. Their cognitive functioning is characterized by speech and language impairments, and they have greater difficulty understanding expressive language than auditory language (Silvia Lanfranchi et al., 2015). As an example, Down syndrome children appear to have more difficulty learning number skills than reading skills. They need personalized learning in numbers due to their slower learning pace. Therefore, the learning outcomes of mathematics curriculum for Down syndrome children should be realistic and suitable to their capabilities. It is because such appropriate and useful skills, especially in maths, can help them to become independent in real life (Wan Fatimah Wan Ahmad et al., 2014).

With that, there are a variety of interventions that have shown positive outcomes for students with learning disabilities, many of the successful strategies are beneficial not only for students with learning disabilities but also for students without learning disabilities; and more research needs to be conducted on strategies to support secondary-level students with learning disabilities in both middle and high schools (Marita & Hord, 2017).

## **METHODS**

The use of scoping review methodology has been widely used for over 18 years. Starting from 1999 to 2012 almost 70% of the scoping reviews were found from 2009 to 2012 (Pham et., 2014). According to Pham et al., (2014), the results of this scoping review show that various terms have been used to describe scoping review in the literature, but it is not limited to scope study, scoping project, literature mapping, scoping exercise, scoping report, evidence mapping, systematic mapping and rapid review.

This diversity of terms results from the lack of a universal methodological definition in the scoping review. For example, (a) Arksey & O'Malley define scoping review as one way to quickly map key concepts to support areas of research, key sources and evidence; (b) scoping review also involve an extensive process of synthesis and analysis of a variety of research and non -research materials in providing clearer evidence on a particular topic or field (Davis, Drey & Gould, 2009); and (c) scoping review intended to provide evidence from a variety of different or heterogeneous sources (Joanna Briggs Institute (JBI), 2015).

The scoping review protocol proposed by Arksey & O'Malley (2005) is the most widely used protocol. Arksey & O'Malley (2010) describe a scoping review as a process for examining the extent and nature of research activity surrounding a particular topic, determining the value of undertaking a systematic review, summarizing and disseminating research findings, and discovering research gaps. This methodological approach serves as a valuable tool for gaining a comprehensive understanding of the research landscape and identifying areas for further exploration in the field.

## Scoping Review Framework

Arksey & O'Malley (2005), developed a five discrete stages methodological framework: identifying the research question, searching for relevant studies, selecting studies, charting the data, collating, summarizing, and reporting the results.

**Table 1** Overview of the Arksey and O'Malley methodological framework for conducting a scoping study

Num	Arksey & O'Malley	Description
1.	Identifying the research question	Identifying the research question provides the roadmap for subsequent stages. Relevant aspects of the question must be clearly defined, as they have ramifications for search strategies. Research questions are broad in nature as they seek to provide a breadth of coverage.
2.	Identifying relevant studies	This stage involves identifying the relevant studies and developing a decision plan for where to search, which terms to use, which sources are to be searched, time span, and language. Comprehensiveness and breadth are important in the search. Sources include electronic databases, reference lists, hand searching of key journals, and organizations and conferences. Breadth is essential; however, the practicalities of the search are as well. Time, budget, and personnel resources are potential limiting factors and decisions need to be made upfront about how these will impact the search
3.	Study selection	Study selection involves <i>post hoc</i> inclusion and exclusion criteria. These criteria are based on the specifics of the research question and on new familiarity with the subject matter through reading the studies.
4.	Charting the data	A data-charting form is developed and used to extract data from each study. A 'narrative review' or 'descriptive analytical' method is used to extract contextual or process-oriented information from each study.
5.	Collating, summarizing, and reporting results	An analytic framework or thematic construction is used to provide an overview of the breadth of the literature, but not a synthesis. A numerical analysis of the extent and nature of studies using tables and charts is presented. A thematic analysis is then presented. Clarity and consistency are required when reporting results.

## Research Questions

Stage 1 identified the research questions: In this study, we asked **‘What are the challenges faced by Down syndrome students in early numeracy?’** As a sub-question, we asked: ‘What are the interventions to support students with Down Syndrome in early numeracy?’

## Search Strategy

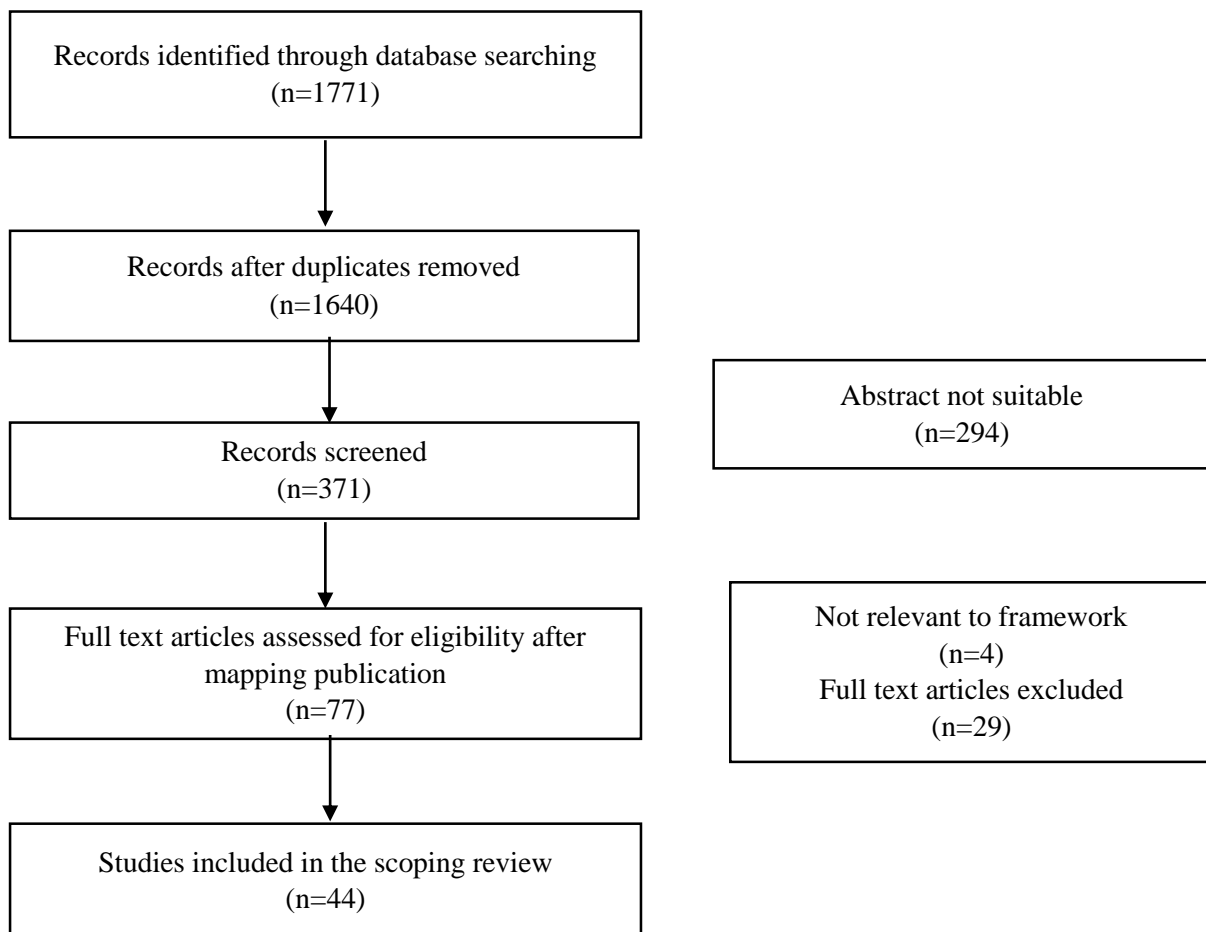
Searches were undertaken in both English and Malay with no geographical limitation using databases, including the ERIC, Google Scholar, PubMed, Ebscohost, Medline, CINAHL and relevant journals for the period from January 2012 to 2022. The key search terms were developed through an iterative process as the reviewers became more familiar with the evidence base. Subject terms used in this search included combinations of 'early numeracy', 'students with learning disabilities', 'early numeracy interventions', 'challenges in early numeracy' and 'early numeracy among Down syndrome'. This initial search was preceded by an analysis of the title, abstract and index terms of the retrieved papers. Secondly, an additional search using the finalized search terms was performed across all databases. Thirdly, hand-searching was conducted to identify studies that may not have been located in the main searches (Hopewell et al. 2007).

## Study Selection

### Charting The Data

Charting the data is to create a descriptive summary of the results which addresses the scoping review's objectives and answers the research questions of the review. The researcher extracted data from the seven included studies into a table with the headings: author, study aims, study design, participants & sample size, key findings and limitations.

**Figure 1** PRISMA flow diagram for the scoping review process.



## RESULTS

44 articles were selected to obtain data related to challenges, interventions, and early numeracy among those with Down syndrome. Nine articles discuss the challenges faced in early numeracy. A total of 21 articles discuss the interventions implemented to improve the level of understanding of numeracy. Next, 14 articles describe the early numeracy of people with Down syndrome.

### Overview study characteristics

#### i. Methodology

A total of 7 articles used qualitative research, 35 articles were based on quantitative research, and 2 articles used a combination of qualitative and quantitative methods.

#### ii. Sample size

There are nine articles using special education teachers as a sample, and another 24 using samples from special education students with learning disabilities. While 11 articles used students with Down syndrome as a study sample.

## REVIEW FINDINGS

Two basic points were analysed in all selected articles. Among the things to look at are challenges and interventions in early numeracy. The results of the analysis show that there are two main aspects to the early numeracy challenge, namely the challenges by teachers and students. Overall, it shows that there are four main interventions that need to be implemented to improve early numeracy.

### Challenges

#### *Challenges by teachers*

Teachers are the main movers in teaching and learning in the classroom. The main challenge for teachers in giving an understanding of numeracy to special education students is the lack of knowledge related to numeracy teaching strategies. A total of five articles discussed how teachers do not know the best ways and methods for imparting numeracy understanding to students. The failure of teachers to master the best pedagogical methods in numeracy indirectly causes students to be unable to master what is being learned. In fact, the five articles also said that the lack of training to improve teacher professionalism caused teachers to lack good classroom management skills. In addition, three articles focus on the lack of collaboration and support from administrators, which causes teachers to be unable to implement teaching and learning well for special education students.

#### *Challenges by students*

The results of the analysis show that there are three main challenges for special education students in understanding early numeracy. Among the three main challenges are short-term memory, weakness in motor skills, and lack of focus or visual impairment. A total of four articles showed that special education students, especially students with Down syndrome, have problems remembering numbers or any information. Very low levels of working memory performance were many times more common in the special-needs sample than in a large sample of children without special educational needs. Deficits in working memory performance were more marked in children with statements of special needs than in those at earlier stages of recognition of the need for educational support. In addition, three articles discuss how weaknesses in gross and fine motor skills are a challenge for special education students in mastering numeracy. Finally, three articles show that special education students are less focused in the classroom due to visual problems.

## **INTERVENTIONS**

Overall, from this scoping review, there are four interventions that are discussed, namely: problem-solving intervention, easy-to-difficult learning level methods, using assistive technology, and empowering teachers with tools and techniques.

### *Problem-solving interventions*

Problem-solving “involves a set of critical control processes that guide an individual to effectively recognize, formulate, and solve problems. This skill is characterized by selecting or devising a plan or strategy to use mathematics to solve problems arising from a task or content, as well as guiding its implementation. There are 11 articles emphasizing the importance of problem-solving in providing numeracy understanding to special education students. This method helps students understand numeracy easily because it involves the process of learning through the environment and existing knowledge of students. The cooperative learning method is also mentioned as one of the methods that can be used in problem-solving interventions. Cooperative learning is the process of breaking a classroom of students into small groups, so they can discover a new concept together and help each other learn. Elements of manipulative skills can also be applied through the method of problem-solving interventions, as suggested by an article that uses gross and fine motor activities in number counting activities.

### *Easy to difficult learning methods*

The results of the analysis showed four articles discussing easy to difficult learning methods as one of the interventions in early numeracy. This easy-to-difficult learning method is implemented to ensure that all students master the expected learning outcomes in a learning unit before moving on to the next learning unit. There is an article suggesting that this method be used one-on-one to ensure that this method is able to improve numeracy comprehension.

### *Assistive technology*

Assistive technology refers to the devices and services that are used to increase, maintain, or improve the capabilities of a student with a disability. There are 6 articles focusing on assistive technology as the best intervention in providing numeracy understanding for special education students. Assistive technology helps in two ways: it can help the student learn how to complete the task, and it can help to bypass an area of difficulty. Among the examples of assistive technology used in the article studied are e-numeracy applications, the use of iPads, touch-point activities, and adaptive gaming.

### *Empower teachers with tools and techniques*

The scoping review analysis showed that two articles focusing on empowering teachers with tools and techniques are interventions that help improve teacher professionalism as well as provide numeracy understanding to special education students. Collaboration among teachers, administrators, and parents plays a role in sharing ideas and opinions in implementing effective teaching methods in numeracy. Both articles emphasize the role of teachers as motivators and facilitators in teaching and learning sessions in the classroom.

## **LIMITATIONS OF THE STUDY**

This scoping review has several limitations. First, the review is limited to research that focuses on students with learning disabilities and Down syndrome. Although the literature search was conducted in multiple steps, it is possible that not all relevant intervention studies were identified. Another possible limitation is publication bias; only studies with large and significant effects are published (Gage, Cook,

& Reichow, 2017). Besides, most of these studies had a single-case design with a small sample size, making it difficult to draw conclusions about treatment effects (Tincani & Travers, 2018). Therefore, the use of the intervention could not be generalized due to the use of a small sample. In addition, to the best of the researchers' knowledge, there is no research being conducted on this issue in the context of Malaysia.

## **DISCUSSION**

The review has indicated that there is a lack of strong evidence on the efficacy and effectiveness of numeracy interventions for students with Down syndrome. Only a few of the specific interventions reviewed have reasonably strong evidence base about their efficacy, that is, their positive impact on student learning. The results of the scoping review show that the main challenge experienced by special education students in numeracy is the difficulty in understanding concepts due to working memory difficulties (Toll & Van Luit, 2013). On the other hand, teachers do not know the best teaching methods for special education students. Instruments for assessing the numeracy comprehension of special needs students were also not being given enough exposure, causing teachers to not be able to make continuous assessments of students.

Teachers are the main pillar in ensuring that every challenge of students with Down syndrome in numeracy can be overcome through various interventions (Faragher & Clarke, 2014). Research agreed that the teacher's knowledge of mathematics has an impact on students' numeracy understanding. Teachers need to have extensive maths knowledge and an understanding of concepts to be able to effectively teach maths to students. The use of approaches appropriate to the student's level of ability helps to improve numeracy comprehension (Muda et al., 2023). Student with Down syndrome are seen to have difficulty carrying out activities that focus on cognition, especially mathematics. This is because they cannot read or write numbers. Through the process of assimilation of number concepts, children need to understand symbols and language that are translated through tangible or intangible objects. Mathematical concepts can also be formed through direct experience and applying aspects of mathematics in real life experienced by children with Down syndrome (Apanasionok et al., 2021). This scoping review has also highlighted some appropriate interventions for overcoming numeracy problems among special needs students. Scoping review results discuss the problem-based learning approach, which is teaching from easy to difficult and applying the concept of constructivism to improve numeracy comprehension. Next, overall articles show the use of play activities, cooperative learning, and visual learning to facilitate special education students' mastery of numeracy effectively. The use of technology in providing an understanding of numeracy is also one of the interventions that have a positive impact on the numeracy of special education students (Ummu et al., 2023). According to O'Keeffe and Paige (2019), there are two main aspects of numeracy, namely connecting students' daily lives and making them critical thinkers. Therefore, in providing an understanding of numeracy, teachers need to present issues and provide opportunities for students to solve them critically. The process of building numeracy understanding will go through the process of constructivism, which is to build knowledge through the experience of the student's own environment.

## **CONCLUSIONS & RECOMMENDATIONS**

In conclusion, addressing the numeracy challenges faced by special education students, particularly those with Down syndrome, necessitates the adoption of a student-centred approach. Implementing student-centred activities, such as game-based learning and technology integration, along with program-based learning, has demonstrated positive effects on enhancing numeracy understanding. The findings of this scoping review offer valuable insights for teachers, parents, and students, aiding them in identifying effective methods to maximize the potential of special education students. Nevertheless, to ensure comprehensive and precise results, further extensive research and exploration of diverse databases are imperative. Furthermore, focusing the keyword search on the Malaysian context and utilizing relevant and suitable samples aligned with the research question will enhance the study's

applicability. Additionally, selecting articles with the most current references will ensure that the review incorporates the latest and up-to-date information.

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