TEACHING NUMBER TRACING TO AT-RISK DYSCALCULIA PUPIL: A SINGLE CASE STUDY IN LINUS 2.0 NUMERACY REMEDIAL CLASS IN SANDAKAN, SABAH

Sai Hoe, Fu
Universiti Malaysia Sabah
fikk221002@hotmail.com

Kin Eng, Chin
Flinders University
kineng.chin@flinders.edu.au

ABSTRACT

This study aims to administrate a qualitative single case study about the teaching of number tracing using a new idea which is known as "Reconnecting Learning-Mediated number tracing". This teaching strategy is developed to teach number tracing and to support pupils at-risk of dyscalculia to master number tracing skills which are a prerequisite to learn number writing. This research blends the active learning theory and mediated learning to form a new teaching strategy. Data were collected from a primary school remedial mathematics Miss Z and a pupil at-risk of dyscalculia in Sandakan, Sabah through lesson observations for synthesizing the pupil's learning progression and conducted semi-structured interviews with the particular teacher. On top of that, analysis of documents such as reflective journals and electronic daily lesson plans (E-rph) was performed in order to gain a comprehensive picture of this teaching strategy. Findings reveal that this new teaching strategy was a structured and practical learning to scaffold the pupil who was at-risk of dyscalculia in particular to number tracing. At the end of this study, the pupil was able to rewrite the numbers correctly using LINUS 2.0 numeracy instrument.

Keywords: *dyscalculia, mediation, reconnecting learning, active learning, mathematics*

INTRODUCTION

Dyscalculia is a specific learning disability that may affect the acquisition of knowledge about numbers and arithmetic (Emerson & Babtie, 2014). It is estimated that about 6% of the population is struggling with dyscalculia (Bird, 2017). For normal kids, the development of mathematical cognition from basic quantitative processing such as subitizing and magnitude judgement to simple arithmetic operations, retrieval of arithmetic facts and lastly is about mathematics reasoning (Thambirajah, 2011). However, Hannell (2013) indicates that children with dyscalculia are poor in numerosity recognition such as they cannot perform subitizing (recognise the small quantities without counting) and counting, slow responses to give answers to mathematics questions, finds it difficult to talks about mathematical processes, has trouble remembering basic mathematics facts, writing symbols and procedure, sequence and confused about position and spatial organization. Moreover, Bird (2017) described that pupils with dyscalculia as they can recite the number sequence without understanding what counting really means, not recognising the concept of cardinality, having a limited sense of quantity and limited numerical magnitude judgement.

Research indicates that dyscalculia may be caused by a brain deficit in the parietal lobe (Butterworth, Varma, & Laurillard, 2011) and dyscalculia tends to happen in families (Shalev, Manor, Kerem, & Ayali, 2001). Interestingly, dyscalculia is found in children born with very low birth weight and it seems to be associated with clear impairments of the left parietal cortex (Isaacs, Edmonds, Lucas, & Gadian, 2001). Also, dyscalculia is related to some genetic conditions such as fragile X syndrome, Turner syndrome and William's syndrome. In the recent years, some of the mathematics educators suggested that the teaching and learning activities should be explicit and that the topics should be broken down into chunks. This is due to pupils with dyscalculia can confidently learn using appropriate materials and visual images (Bird, 2017; Emerson & Babtie, 2014; Hannell, 2013; Thambirajah, 2011). However, there is no significant research to show which teaching strategy is effective to assist the at-risk pupils with dyscalculia to master the basic numerosity processing and writing numbers. Therefore, this paper is probing into the ways of scaffolding at-risk pupils with dyscalculia to learn number tracing.

LITERATURE REVIEW

Developing writing number skill is one of the numerical skills that will assist to prepare the young learners for the style of work they will meet in level two (primary four to primary six) school years and enable them to work independently (Bird & Buckley, 2001). However, summarizing learner's understanding or thinking in writing scaffolds deep cognitive process. In short, writing number is difficult and the act of writing number needs not only deep thinking but also processing numerical knowledge (Pearse & Walton, 2011). Children will be able to learn how to write numerals through paper and pen activities. Some more, children will benefit from support to understand the number such as work with number stickers and other replacement for written numerals (Bird & Buckley, 2001).

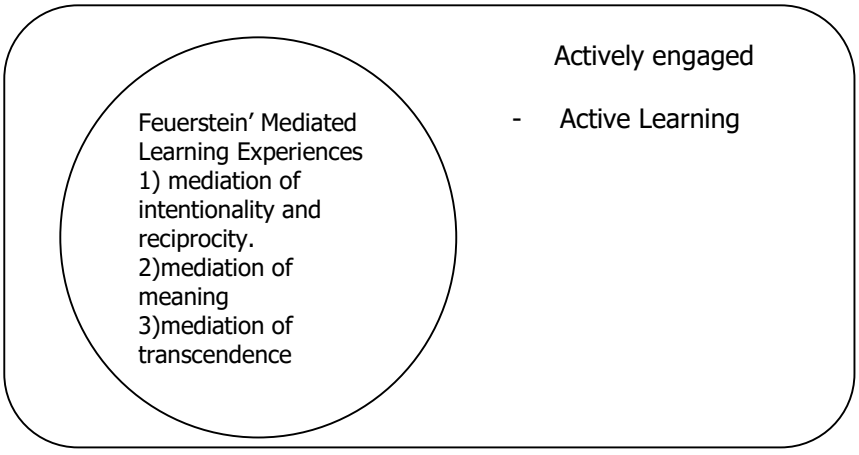

Figure 1. Conceptual framework of Reconnecting Learning

The conceptual framework of this paper (see Figure 1) stands on the blending of active learning and Feuerstein' Mediated Learning Experiences to create a new teaching strategy. Active learning is about engagement in a guided teaching and learning activity which promotes brainstorming and subsumes knowledge instead of sitting passively and receiving all the information from the teacher (Conklin, 2014). In learning mathematics, active learning provides pupils with the chances to become actively engaged in learning mathematics by manipulating teaching and learning materials, making connections to real-world applications and addressing their learning disposition and multiple intelligence (Martin, 2007). Feuerstein (2015) proposed that there are three main parameters of Mediated Learning Experiences (MLE): 1) mediation of intentionality and reciprocity means the "mediator" mediated the learners to engage with stimuli (intentionality) and reciprocity is that responsively from the learner during their feedback, 2) mediation of meaning is referring to the mediator gives a key point to understanding the meaning of stimuli, 3) mediation of transcendence means that every single moment has in it the potential for bridging the ideas.

The key point of mediation is to observe and listen to children in order to determine where they are in the learning cycle and then to intervene with a task or challenge as a catalyst for modifying learners' thinking both cognitively and motivationally and causing the child to learn (Feuerstein & Lewin-Benham, 2012). Most children who move from lower to higher cognitive functioning have been mediated by showing children the precise way to use a tool; encouraging children to think about the content or meaning, asking children to reason using their own words (Feuerstein & Lewin-Benham, 2012).

After reviewing the literature of active learning and Feuerstein' Mediated Learning Experiences in helping dyscalculic pupils, the researchers proposed a teaching method "Reconnecting Learning - Mediated Writing Number" to help the at-risk dyscalculic pupils to learn number tracing by expressing the number magnitude in a number system. Reconnecting Learning - Mediated Writing Number is one of the new teaching methods aims to help dyscalculic pupils to learn tracing numbers through mediation and active learning. Firstly, the teacher acts as a mediator to mediate the meaning of number to the at-risk dyscalculic pupil, then the teacher acts as a facilitator to scaffold the at-risk dyscalculic pupil to trace the numbers. Here the researchers argue that dyscalculic pupils should undergo the process of intervention in order to activate existing knowledge and to get guidance from the mediator before they can proceed to construct and consolidate their skill of tracing number.

Dyscalculia is one of the learning disabilities which caused by a brain deficit in the parietal lobe (Butterworth et al., 2011). Yet, Feuerstein and Falik (2010) claimed that the human beings are modifiable. Our brain plasticity allows the brain to rebuild connections that are interrupted or underdeveloped by trauma, disease, or genetic conditions (Falik & Feuerstein, 2010). Moreover, Boaler & Dweck (2016) also pointed out that when a learner learns new things, a synapse connection will emerge in our brain and form a structural pathway. In general, Feuerstein' Mediated Learning Experiences means to permanently change how learners think and unlock their potentials by making new connections between experiences or stimuli, understand the role of ideas or objects in diverse contexts and obtain the meaning of objects (Feuerstein & Lewin-Benham, 2012).

METHODOLOGY

This study administrates a single case study research design to gather relevant qualitative data. It was implemented at one of the national primary schools in Sandakan District, Sabah. One remedial mathematics teacher, Miss Z who had more than 11 years of teaching remedial classes and one primary two at-risk dyscalculic pupil who was eight years old were chosen purposely in this study. They were involved in this remedial activity on a voluntary basis. For the purpose of this study, the researcher obtained parental consent and teachers consent by sending the informed consent letter and a letter of information about the study to children's parents and the teachers. The selection of teaching materials and content are highly influential to the development of pupils' understanding of the number tracing. For the learning of number tracing, learning materials such as flour and a tray are essential for fostering at-risk dyscalculic pupils' hands on experience and developing pupils' cognitive level. Data were collected through observation, interview, and document analysis. The objectives of this study are to explore how "Mediated writing number" help at-risk dyscalculic pupil in learning number tracing and how are the teacher's perceptions about this teaching activity. Hence the research questions for this study are (1) How "Mediated writing numbers" help learner in learning number tracing has been implemented? (2) How did the teachers react to the new innovative teaching activity? The researchers collected the data from a single case study and then the data were interpreted in an integrated manner in order to answer the above research questions.

FINDING

Participant Background

The researcher collected all the related documents such as analysis construct in portal NKRA (National Key Results Area) (see Document 1), the medical reports (due to research ethical issues and protect the participant's authority, the medical reports will not be shown in this paper) to identify the at-risk

pupil with dyscalculia and how the teacher prepared for her lesson by drafting her electronic daily lesson plan (ERPH) in virtual learning environment (VLE) (see Document 2).

15. H	090211120697	C L	✓		L-BM		✓											Tidak Menguasai (K1-K2)	
					N		✓											Tidak Menguasai (K1-K2)	
					L-BI		✓											Tidak Menguasai (K1-K2)	

Document 1: Analysis constructs in portal NKRA

Miss Z is a mathematics teacher with nine years of teaching experience and she received her teaching degree in one of the teacher training campuses in Malaysia. She has four mathematics period with Pupil H weekly which means that she has 120 minutes teaching and learning session weekly.

From the findings, the researchers synthesized the participant's responses through the interviews data, blended with the observation data and document analysis and came out with one main theme and three sub-themes in answering research questions number one: "How "Mediated writing numbers" help learner in learning number tracing has been implemented?", and one theme in answering research questions number two: "How did the teachers react to the new innovative teaching activity?". The two themes are: Reconnecting learning is 1) structured learning with three steps: demonstration, mediation and active learning and 2) practical and motivated learning.

STRUCTURED LEARNING

Demonstration

The demonstration approach is one of the most common teaching techniques to introduce a new topic and promotes interaction among students and teachers. The learners are induced to think and reasoning and come put with their viewpoints as well.

In school A, the researcher visited Miss Z in class with primary year 2 at-risk pupil with dyscalculia. The strategy selected by the Miss Z was "Reconnecting Learning - mediated number tracing". From the beginning of the lesson, Miss Z prepared a plastic storage container and some flour. Pupil H was so excited and urged to touch the flour. Then, Miss Z intentionally told Pupil H about today's learning goal which was tracing number 1 to 9. Pupil H looked at Miss Z and nodded his head to show he received the information and he readied for the lesson. Following by Miss Z demonstrated how to trace the number using her finger on the flour to Pupil H. Miss Z would concentrate on demonstration, mediated learning and pupils' actively learning during the number tracing lesson. The best picture taken during the classroom observation is the best evidence to show that Miss Z did use demonstration in her lesson confidently (see Figure 1).

Figure 1. Miss Z demonstrated how to trace number 5 using her index finger

Miss Z showed her demonstration in teaching and learning number tracing. To be exact, Miss Z presented saying that she made application of demonstration in her induction set as illustrated in her interview extract below:

> "First of all, I will ready …I will prepare the plastic container, then I put some flour inside the container. Arr… I asked pupil H to put his attention on what am I doing. Look at here, teacher wanna to trace a number 5… then I used my index finger to write number 5 in front of pupil H."

From her interview excerpt, it was obviously shown that Miss Z repeatedly mentioned "I will" and subsequently, she said, "Look at here". What Miss Z meant was she did use demonstration teaching technique in her teaching and learning lesson. Then, Miss Z mentioned the preparation of the materials (the container and the flour) and to promote Pupil H to observe and visualize the process of number tracing. Miss Z was trying to say that confidently she applied the demonstration strategy in her daily lesson plan. It is parallel to Basheer (2016), demonstration refers to the type of teaching method in which involves illustrating key points in a lesson by means of something other than routine visual aids or other means of instruction. Here, the teacher explains and shows the learning process step-by-step to the learners (Chikuni, 2003). Hofstein and Lunetta (2004) drew to the conclusion that demonstrations have the potential to enhance learning, motivation, and attitudes in their comprehensive reviews.

Likewise, Miss Z also wrote demonstration strategy in her daily lesson plan that she demonstrated explaining that the pupils need to observe the way of number tracing in this case. This is best illustrated in the following example (Document 2) of the daily lesson plan about using demonstration from Miss Z:

Pupil's name:
Class: 2 Elite
Date: 31 Jan 2018
Time: 8.00 - 815
Topic: Number Tracing (1-9)

Teaching	Demonstration -The teacher and pupil sing the number song 1-10 -The teacher prepares the flour and container -The teacher demonstrates how to trace number 1 - 9 on the flour surface Mediation -The teacher traces number 5 and say "five" on the flour surface. -The teacher grabs pupil's hand to trace the number. -The pupil read after the teacher "five" and "two". -Repeat with 2 and 3,4,5,6,7,8,9 Active learning -The pupil is asked to trace the number. -The pupil is asked to say the number after tracing

Document 2: Miss Z s' daily lesson plan

Mediation

Miss Z demonstrated mediation during her lesson. The researcher's field notes about Miss Z mediated Pupil H during the second step of the lesson and she clarified this:

Then, Miss Z grabbed Pupil's right hand to trace number on the flour surface using his own index finger (see figure 2). Pupil H felt so enthusiastic and he had been motivated to trace the numbers on the flour. Once again, Miss Z lead pupil H to read after the name of the number -one to ten and pointed with the corresponding numeral as well. In this stage, Miss Z was implementing the mediation of transcendence to link the name of the number -one to ten with the corresponding numeral. The researcher also

observed that while learning a number tracing from one to ten, a learner may also learn about the number words and the number which represent the number magnitude.

Figure 2. Miss Z grabbed Pupil's dominant hand to trace the numbers on the flour surface using his index finger.

Active Learning

After mediating pupil H with the knowledge of tracing numbers by grabbing Pupil H's dominant hand to trace the numbers, Miss Z proceeded to teach pupil H with number writing using active learning skill. Miss Z demonstrated again by tracing number. Then, pupil H was asked to trace his favourite numbers on flour surface in order to construct his own interpretation of the numbers through this practical experience which included his physical movement and visualization (see figure 3).

Figure 3. Pupil H traced actively number 5 by his own index finger

Interestingly, pupil H correctly traced " 1, 2, 3, 4 " in Arabic digits. Then, when Miss Z asked pupil H again: "What is the number next to 4?" Pupil H looked on the ground and paused for a while then he answered: "five" in the Malay language. Miss Z asked: " Can you trace number 5?" Pupil H wrote number 5 in mirror images. This situation is paralleled to Emerson & Babtie (2014)'s statement that an at-risk dyscalculic pupil has the symptom of writing numbers in mirror images.

Miss Z described her observation about Pupil H's progression in learning number tracing as seen in her reflection journal wherein that she finally knew pupil H needed three times of repetition and practice to write the number 5 correctly. Here is the extract from her reflection journal:

LEARNING	Selesai aktiviti *demostartion* dan *mediation,* Hidayat cuba untuk menulis nombor yang saya sebut dari nombor 1 hinggalah sepuluh. Dalam sesi *active learning* ini, Hidayat boleh menulis nombor dengan penuh ketekunan. Semasa menulis nombor 5 saya dapati dia menulis nombor tersebut dalam keadaan terbalik. Saya minta dia menulis semula hingga 3 kali untuk memperbaiki nombor terbaliknya.

After the demonstration and the mediation, Pupil H tried to write the numbers 1-10 that as instructed by the researchers. During the active learning session, Pupil H was able to write the numbers with diligence. The researchers found that Pupil H wrote the number 5 in the mirror image and asked Pupil H to rewrite the number 5 three times to improve his number writing.

Document 3: Miss Z's reflective journal about Pupil H need three times of repetition in writing number 5.

Miss Z pointed to the number 9 which was traced by Pupil H and asked: "what number is it". Pupil H answered "nine" with full confidence (see Figure 4). Miss Z repeated her question with requesting Pupil H to trace number 5. Surprisingly, Pupil H traced the number 5 correctly and answered: "five " as well. Miss Z continued to ask: "How about you trace your favourite numbers and name it?" Pupil H started to trace and said:" 2 (two), I have two cats in my house." in the Malay language. Amazingly, pupil H can master the number tracing with linking the numbers with the daily life that he has two cats in his own house.

Figure 4. Pupil H traced number 9 on the flour surface

After the teaching and learning sessions, Miss Z assessed pupil H by asking him tried to rewrite the number using a pencil. Pupil H wrote 2, 5, 7 correctly with teacher's guidance (see figure 5). It was so great that pupil H mastered the number tracing correctly after the remedial session.

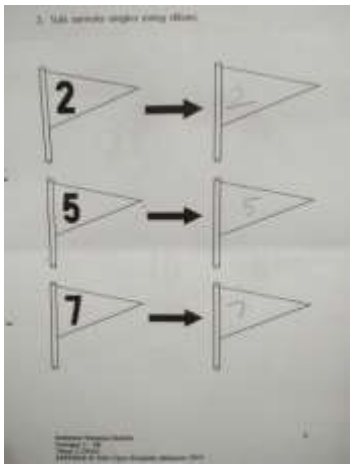

Figure 5. Pupil H wrote the numbers correctly

Practical and Motivated Learning

From the interview transcript, Miss Z said: "I feel this new teaching method is more practical to teach number tracing for my pupil. Hmm… I found that Pupil H was excited and eager to touch the teaching materials- the flour without my instructions. Haha… for me is a good sign that Pupil H is willing to learn autonomy."

She continued: "This activity helps my pupil especially the weak pupil, for example tracing number, I noticed that Pupil H has encountered difficulties in tracing number 5 in a mirror image. After a few attempts of mediation and guidance, he is able to trace the number 5 correctly during the last step of the lesson - active learning.

In addition, she described: *"Argh…I feel that it is much easier to prepare the flour rather than using sand during the number tracing. I can just bring some flour form my house rather than digging sand from my backyard".*

Miss Z delivered good points that in the interviews: *"I found this teaching method can help pupil H to increase his concentration and attention on this activity since it is a one to one teaching session, he is so focusing on writing and tracing on the flour surface. He felt so free to do whatever he likes to do as I asked him to trace his favourite number. Other than that, the most precious moment of this teaching and learning session is about I am grabbing his hand to mediated him in order to trace the number, he felt he is valued and my care for him as his remedial teacher."* She continued: " *He felt like my teacher is holding my hand, she is supporting my study and learning, I have to pay more attention in my study."* At that moment, he has maybe been motivated to learn initiative to trace the number 5 repeat at three times. It is the most wonderful moment when I notice his good attitude and desire for learning.

DISCUSSION

From this case, the researchers highlighted two issues in this discussion. There were: 1) This teaching strategy is a structured learning with three consecutive steps in order to scaffold at-risk Dyscalculic learner to learn number tracing 2) This teaching strategy is practical in the remedial classroom with one to one setting and can motivate the pupil to learn initiative. The teaching method proposed in this paper is structured because it consists of three consecutive steps which are the demonstration, mediation and active learning. As noticed in the interview transcript: "First of all, I will ready …I will prepare the plastic container, then I put some flour inside the container. Arr… I asked pupil H to put his attention on what am I doing.". The following field's note analysis: Then, Miss Z grabbed Pupil's right hand to trace number on the flour surface using his own index finger shown that the mediation of meaning happened to

scaffold at-risk Dyscalculic pupil to learn the number tracing. Corresponding with Feuerstein & Lewin-Benham (2012), Mediated Learning Experiences support learners to retrieve a new concept to achieve the learning goal by three main factors such as mediation of meaning, mediation of transcendence and mediation of intentionality and reciprocity. Furthermore, the active learning occurred when Miss Z assessed pupil H with asking him tried to trace the number using his finger and rewrite the number using a pencil. Pupil H wrote number 2, 5, 7 incorrectly during the observation. Pupil H showed that he constructed his own knowledge in this circumstance by tracing number on top of the flour surface and stored the numerals in his working memory as suggested Conklin (2014) that active learning can extend learners' active experience, time involvement and arouse their desire of learning so that they can subsume their prior knowledge and the new experiences then apply in a new situation.

Generally, when there is no motivation to learn, there is no acquisition of academic knowledge or socials skills. With motivation, a child is driven to understand and have urges to learn (Riccio, 2014). Hence, a practical teaching activity should cultivate pupil's interest and motivation of learning so that the learner may prolong his learning time to achieve the learning goal. We synthesised that Miss Z implemented this teaching method practically and systematically as her lesson plan was so organised and parallel to what she was implementing during her lesson and using flour in her number tracing lesson. Miss Z highlighted the uses of mediation by tracing number on the flour surface to assist pupil H to trace numbers.

CONCLUSION

As a conclusion, this case study has described how the "Reconnecting Learning - Mediated Learning" activity has been implemented in a remedial class by providing details of the new teaching strategy which can impart number tracing to the at-risk Dyscalculic pupil. The participant felt this activity was a good start to support the at-risk pupil with dyscalculia in learning number tracing affective and cognitively. She was attracted by the connection between the idea of chunking the teaching and learning activity into three parts such as demonstration, mediation and active learning. On the other hand, pupil H was motivated to learn number tracing by observing and assessment, guided by Miss Z. At last, pupil H was able to rewrite the numbers correctly during the assessment even though he needed more time to wrote the number five and number seven. Therefore, it can be concluded that this remedial activity was one of the practical new teaching methods to assist the at-risk dyscalculic pupil in learning number tracing.

REFERENCES

Basheer, A. (2016). The effectiveness of teachers use of demonstrations for enhancing students understanding of and attitudes to learning the oxidation-reduction concept. *EURASIA Journal of Mathematics, Science and Technology Education, 13*(3).

Boaler, J., & Dweck, C. S. (2016). *Mathematical mindsets: Unleashing students potential through creative math, inspiring messages, and innovative teaching*. San Francisco, CA: JB Jossey-Bass.

Bird, G., & Buckley, S. (2001). *Number skills development for children with Down syndrome (5-11 years)*. Southsea: Down Syndrome Educational Trust.

Bird, R. (2017). *Dyscalculia toolkit: Supporting learning difficulties in Maths*. London: Sage Publications.

Butterworth, B., Varma, S., & Laurillard, D. (2011). Dyscalculia: From brain to education. *Science, 332*(6033), 1049-1053. doi:10.1126/science.1201536

Chikuni, B. (2003). *The teacher's handbook. A practical approach to teaching.* Gwanda, Zimbabwe: Flame Publishers.

Conklin, W. (2014). *Active learning across the content areas*. Huntington Beach, CA: Shell Education.

Emerson, J., & Babtie, P. (2014). *The dyscalculia solution: Teaching number sense*. London, UK: Bloomsbury Education.

Feuerstein, R. (2015). *Changing minds and brains: The legacy of Reuven Feuerstein: Higher thinking and cognition through mediated learning*. Australia: Hawker Brownlow Education.

Feuerstein, R., & Falik, L. (2010). Learning to think, thinking to learn: A comparative analysis of three approaches to instruction. *Journal of Cognitive Education and Psychology. 9*, 4-20.

Feuerstein, R., & Lewin-Benham, A. (2012). *What learning looks like: Mediated learning in theory and practice, K-6*. New York, NY: Teachers College Press.

Hannell, G. (2013). *Dyscalculia: Action plans for successful learning in Mathematics* (2nd ed.). Oxon, UK: Routledge

Hofstein, A., & Lunetta, V. N. (2004). *The laboratory in science education: Foundation for the 21st century*. Science Education, *88*, 28-54.

Isaacs, E. B., Edmonds, C. J., Lucas, A., & Gadian, D. G. (2001). Calculation difficulties in children of very low birth weight: A neural correlate. *Brain 124,* 1701–1707.

Martin, H. (2007). *Active learning in the mathematics classroom, grades 5-8*. Thousand Oaks, CA: Corwin Press.

Pearse, M., & Walton, K. M. (2011). *Teaching numeracy: 9 critical habits to ignite mathematical thinking*. Thousand Oaks, Calif: Corwin.

Riccio, L. L. (2014). *For what child*. Rotterdam: Sense.

Shalev, R. S., Manor, O., Kerem, B., & Ayali, M. (2001). Developmental dyscalculia is a family learning disability. *Journal of Learning Disabilities, 34*, 59–65.

Thambirajah, M. S. (2011). *Developmental assessment of the school-aged child with developmental disabilities: A clinicians' guide*. London: Jessica Kingsley.