

A Meta Synthesis On Dyscalculia Phenomenon

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Abstract

This meta-synthesis study from published qualitative studies regarding dyscalculia (mathematics disability) is to characterize learners with dyscalculia and the possible reasons for this disability. Based on the set criteria, seven (7) case studies were selected from different countries with subjects between seven to eleven years old having symptoms and characteristics of the disability. The case analysis revealed that dyscalculia is potential in any place, race, age and gender. It could be caused by another disorder, genetics, psychological or environmental factors. Learners with dyscalculia had difficulties on number concepts, counting, sequencing, basic facts and misunderstanding of terms and processes. The studies introduced varied interventions such as classroom and specialized activities and computer programs which were effective in improving the children's mathematical skills with the support of the parents, teachers and the school administration. A management model for a school mathematics remediation program was recommended.

Introduction

Learners usually have fear in Mathematics and are unable to understand the basic concepts of mathematics due to various reasons. The problem of learning mathematics is relatively more than learning other subjects. Thus, mathematics becomes a tougher subject and learners tend to avoid it as mentioned by Goswami, Hazarika and Sarma (2012). It is also a subject wherein teachers and learners will always have misconceptions and misunderstanding as cited by Sarma and Ahmed (2013). Students may find mathematics frightening that may create bigger issues in learning. Even if teachers find ways to resolve the issues at the earliest possible time, students who continuously practice and study mathematics still have struggled in the examinations resulting in fear in the subject.

In the late 1990's researchers in the cognitive sciences found out that there are cases of serious learning difficulty in mathematics (Siegler, 2003). They believed that this is not learning difficulty but a learning disability and is better known as dyscalculia in which children show particular disabilities in learning math (Ansari & Karmiloff-Smith, 2002). Dyscalculia is a state where learners have difficulty in acquiring mathematical skills in spite of proper instruction. Learners find it hard to understand the concepts of mathematics. They have difficulty in grasping and retrieving procedures and using numbers. They may have correct answers in the examinations but still they are not confident of themselves as cited by Chinn (2004). This is a challenge for the learners with dyscalculia when it comes to numbers and doing mathematical tasks.

Bird (2009) points out that the learners with dyscalculia have no idea how to solve mathematical problems and do not care whether the answer to a mathematical problem is right or wrong. He has identified indicators for learners with dyscalculia such as the following: (a) learners perceive with counting even if small digits; (b) learners are very weak in their memory both short-term and long-term and visually; (c) learners have trouble in sequencing and have muddle in directions; (d) learners have problem in identifying and counting money and cannot tell and read time. They have trouble in the number series and sequencing of numbers, such problems allied to the recall and memorization of numbers are noted among (Shalev, 2004 - Piazza, Facoetti, Trussardi, Berteletti, Contee, and Lucangeli (2010). Additionally, Cipolotti, Butterworth, and Denes (1991) strengthen that they are poor in mental and written arithmetic operations and inadequacy of mathematical functions (Periklidakis, 2003). For their short-memory they are enabled to calculate simple mathematical problems in basic operations (Rosselli, Matute, Pinto, & Ardila, 2006). These also lead to problems in the correct use of arithmetic signs, telling of time, and memorizing math formulas and facts, such as the multiplication tables (Munro, 2003).

With the various studies, this meta-synthesis study analyzed seven case studies of learners with dyscalculia in order to identify their dyscalculic characteristics, find out the probable causes and determine the interventions used to improve their mathematical skills as addressed by the experts in education, special education workers and other persons who are interested in this phenomenon.

Method

Meta-synthesis method was employed in accomplishing the model of published qualitative research reports regarding individuals with dyscalculia or dyscalculic tendencies and other methods with learners that have mathematics disability or difficulty. As described by Sandelowski, Docherty, and Emden (1997) meta-synthesis is achieved by carefully coming off the qualitative studies surface layers to find the core and depths that would least damage to the themes. Additionally, meta-synthesis underwrites the practice of coming out to a point about a specific phenomenon.

Noblit and Hare (1988) outline seven phases in constructing of a meta-synthesis: (1) decide the main point or the phenomenon of the study; (2) research literature; (3) feel on how well the phenomenon is being address by rating them; (4) cross match them to determine the relational similarities and differences of each phenomenon; (5) compare the study results but leaving the individual metaphors and intact; (6) categorically synthesize and develop themes; (7) communicate the synthesized result.

The study is anchored on a philosophical stance. A philosophical stance is our state of being and relationship to others, as well as the way we think about and the way we talk and respond to others (Anderson, 1997). A 'philosophical stance' therefore epitomizes the way of seeing and experiencing the world but subjectively adamant by our beliefs and partiality: In which our own and social attributes are convoked. (Anderson, 2007)

The holistic point of view of the researcher to the learners with dyscalculia whether the researcher has treated them equally or has no bias and was not carried by the situation. In any qualitative study, biases should not be present and do not put yourself in the respondent's shoes. Researchers should stand firm in any activities during the research process to have valid and reliable information or data.

The selection criteria should be accurate to represent the substantive domain of inquiry as well as consider that the gradation of different operational characteristics can be implicitly combined into a conjoint metric according to Lipsey and Wilson (2001). The study utilizes published research reports from different international journals of countries like Brazil, Brunei, Canada, Italy, Malta, Maldives and United States of America on the topic of dyscalculia. During the years 2000 to 2015 that qualify the following criteria. (a) focus on standpoint in relation to the behavior and characteristics of individuals with dyscalculia; (b) only children and teens participants in a school setting; (c) use one or more qualitative research approaches; and (d) support the research findings relevant to other qualitative data.

Table1 shows the selected studies for meta-synthesis.

Table 1. *Selected Studies for Meta-synthesis*

Authors	Year Published	Title	Research Locale
<i>Nigel Price & Simon Youe'</i>	2000	<i>The Problems of Diagnosis and Remediation of Dyscalculia</i>	<i>Ontario, Canada</i>
<i>Elizabeth Wadlington & Patrick L. Wadlington</i>	2008	<i>Helping Students with Mathematical Disabilities to Succeed</i>	<i>USA</i>
<i>Esmeralda Zerafa</i>	2011	<i>Helping Children with Dyscalculia: The Implementation of a Teaching Programme with Three Primary School Children</i>	<i>Malta</i>
<i>Lawrence Mundia</i>	2012	<i>The Assessment of Math Learning Difficulties in a Primary Grade-4 Child with High Support Needs: Mixed Methods Approach</i>	<i>Brunei</i>
<i>Mohamed Sujaau</i>	2014	<i>DYSCALCULIA: A Case Study and Intervention Plan</i>	<i>Maldives</i>
<i>Daniela Lucangeli, Patrizio Tressoldi and Chiara de Candia</i>	2005	<i>Education and Treatment of Calculation Abilities of Low-Achieving. Students and Students with Dyscalculia: Whole Class and Individual Implementations</i>	<i>Italy</i>
<i>Robert Peard</i>	2010	<i>Dyscalculia: What is its prevalence? Research evidence from case studies</i>	<i>Australia</i>

The synthesis is derived by maintaining the main point of each study and comparing it to other main points in the results. Researchers have the possibility to infer the strengths and limitations of the study and to provide alternatives. Fittingness is reached when the meta-synthesis findings can fit into other contexts as well as reflect elements of life experiences. (Bondas & Hall, 2007).

Classic method in constructing a meta-synthesis of Noblit and Hare (1988) was followed in analyzing the qualitative published research reports of the seven (7) selected studies. Then themes were developed through constant comparison of similarities or differences of the contents of the studies. In case two themes are the same in two studies, the two themes will be articulated based on its kind and difference. For that instance, sub themes will be created.

Results and Discussion

The following themes were developed from the seven case studies of learners with dyscalculia.

Dyscalculia in any place, race, age, and gender

According to Hadhazy, 6 percent to 8 percent of the world population have dyscalculia (Hadhazy, 2011). Thus, the seven studies in this paper came from different parts of the world. Unfortunately, not one study from the Philippines is published. The seven single case studies revealed that as early as seven years old, dyscalculia can be detected among boys or girls. Children with dyscalculia had almost the same characteristics and symptoms as diagnosed by the researchers as experts. Diagnosis was formally done by giving examinations or informally done through school records, clinical history and interviews with parents and teachers or specialists if they have any. The studies also revealed that some children with dyscalculia have siblings or relatives with the same disability.

Disorder Begets Disorder, Causes of Dyscalculia

Of the ten learners with dyscalculia seven were found to have another disorder, either dyslexia, dyspraxia, dysgraphia, ADHD or OCD which were believed to be one of the causes of dyscalculia. Based on a research study that 10% of learners with dyslexia are excelling in mathematics and about 40-50% doesn't cyphers dyscalculia. The difficulty is not much more in the concept but in the language of mathematics. (Dyslexia Association of Ireland, 2010)

Dyscalculia is a common difficulty that dyslexic children often encounter. In fact, according to Chivers (2001), "around 60% of dyslexics have difficulties with dyscalculia" and such problems are not often reported or tackled well. According to several researchers, some learners with dyscalculia significantly progress when different math concepts are taught and earlier treatment yields better progress (Kaufmann, Handl&Thöny, 2003).

Another possible cause of dyscalculia is genetics which means that this could be inherited. In Zerafa's study (2011) one of the girls has a sister with the same disability and a boy in Suajuu's (2014) study also had a brother with mathematical disability. Like any other learning disabilities, a genetics study by Shalev, Manor, Kerem, Ayali, Badichi, Friedlander, and Gross-Tsur (2001) have concluded that dyscalculia is also acquired hereditarily. The study of Morin (2014) strengthened factors affecting dyscalculia and identified it's a brain-based condition and common in some families. Meanwhile Fletcher (2007) said dyscalculia may be genetic and other researchers also found out that dyscalculic children often have parents or siblings with the same disability. Using the modern imaging tools in studying the brain researchers found surface area difference and volume and thickness in parts of the brain. The areas are for memory and learning, which affects how learners set up and remember math tasks and facts (Ranpura, Isaacs, Edmonds, Rogers, Lanigan, Singhal, Clayden, Clark, & Butterworth (2013). Underweight and premature born babies (Shalev, 2004) and taking alcohol during pregnancy (Wilson, 2015) can lead to dyscalculia.

There is an apprehension of the parents that unborn siblings would likely have dyscalculia or other disabilities like dyslexia or others, as it was found that it is interconnectivity among the same genes. For that reason, parents do not like having another member or child in the family.

Different learners, different disabilities

With the seven case studies, learners with dyscalculia vary in the degree or level of their disability and difficulty in mathematics learning, it ranges from severe to very severe or poor to very poor. Or it could be only the concept of basic mathematical operation as revealed in the studies. Some learners showed loopholes in number isolation of variables and their relationship, translation of numbers into words and vice versa, and ordering of quantity which evidently manifests poor comprehension in number sense. Some difficulties involve mental calculation strategies, written calculation procedures, recall of arithmetical facts, lexical, and semantics mechanisms.

One child used incorrect procedures confusing addition instead of multiplication and is very slow especially in oral calculation than in written computation. He has difficulties with quantity comparison, and in lexical processes (the dictation of numbers), and in retrieving numerical facts. Other learners have difficulty in the conversion of volume, simple addition, and subtraction especially on fractions, concepts about money, counting and reverse counting, identification of shapes, and estimating and conversion of measurements.

The math teacher should be a master of his/her field of specialization in order to comprehend every learner's needs. For a teacher of a dyscalculic learner in a normal classroom setting, he/she will have a hard time managing. Learners with dyscalculia need to be individualized, as their learning difficulties vary.

Multi-faceted role of a Math teacher

Mathematics teachers vary in their commitment and teaching to children's learning. As mentioned in one of the studies, teachers tend to assume that if the child did not perform well in class, then they are just below average without thinking of learning disabilities of the learners. Many mathematics teachers are not trained to assess dyscalculic symptoms of their learners. Mundia (2012) suggested that mathematics teachers should be aware of these special needs of learners so they should attend initial and continuous training programs. With this knowledge and skill, they can highly help support the needs of learners in learning mathematics.

Some mathematics teachers may recognize the weaknesses of the learners with dyscalculia. However, addressing the learners' learning disabilities is very tough and challenging due to the number of learners in a class. One teacher just gave comments in the report book comments for math and wrote that the "*he needs to memorize the multiplication table.*" This was difficult and ineffective for a learner who was weak in memory. The teacher had not tried other methods to teach mathematical concepts.

What is more challenging when dealing with learners with dyscalculia is that a teacher becomes a tutor. Tutoring should be done on a one-to-one basis in order to attain a degree of accomplishment. As a tutor, one needs more time and effort to make the instructional materials separate from the regular class. A tutor needs to provide special assistance and analyze specific issues that the learner encounters when tackling problem solving tasks. Hence, a special tutor is recommended to assist the learner.

The most important role of a teacher is to know his/her student in order to address his/her unique needs, ability, social interaction, interests, background and disabilities (Lanier, 1997). These where individualized learning or one-on-one learning comes in. The teacher becomes a tutor, a friend, a guardian and facilitator of learning. This implies that teachers have a great impact on the child or the whole being of a person.

Different Parents, Different Strokes

The home and school are the two (2) environments in which the learners are molded and developed. At home, they are closely monitored and always at the look out of the parents. Parents with high educational attainment help their children with school work. Parents with low educational attainment rely on the teachers. One mother of a child with dyscalculia, made a detailed diary or journal regarding her child's behavior and progress in school. Three of the learners were referred by their parents to specialists and were provided tutors. However, there was a mother who never cared how her child was doing in school and said "*It is the teacher's job.*" According to Edelman (2006, as cited by Wairimu, Macharia and Muira, 2016) "*Parents are confident enough that educators know what is best and what is not for their children.*"

The studies emphasized that for learners with dyscalculia, parents are needed to get involved and be partners of the teachers for the child's learning. What they need is clinical history of their child, enhance their education measurement and during diagnosis of their child they should be around to observe. In other words, they should involve themselves every step of the way.

Interventions in Mathematics Teaching

Price and Youe (2000) expressed that "*every dyscalculic child is unique*". The aim of remediation in the classroom is to develop individualized strategies, varied programs and procedures, self-centered tasks in order to address and correct the levels of every dyscalculic child. With the seven studies, the following mediations were identified:

Appropriate Diagnosis. To achieve appropriate diagnosis, it's a "no...no" error in the analysis and diagnosis of every dyscalculic child (Mundia, 2012). Moreover, assessment is the first phase of any programme (Zerafa, 2014) and the most crucial part, it determines and explains every child's potential and unlocking his/her weaknesses in the learning of mathematics (Henderson, Came, & Brough, 2003).

Use of multi-management classroom activities and exercises. Chinn (2004) suggested variations of methods, strategies, and approaches should be employed. Suggestion is to make use of a multisensory approach in

mathematics teaching and learning. And it is necessary to have constant evaluation of the interventions used to identify which strategies and approaches fitted to children and which are not.

Anti-math anxiety activities. All the studies recommended are to lessen math anxiety among the learners. Some of the highly suggested activities are cooperative learning, peer tutoring, words of appreciation and recognition, peer tutoring and positive reinforcement which will help him stimulate and intensify his curiosity in mathematics thereby decreasing anxiety and phobia (Mundia, 2012) which will eventually achieve progress and success.

Semiotic mediation. As suggested by Vygotsky (1986: as cited by Ahlcrona and Samuelsson, 2014), language basically guides learners from what they already knew to what to be learned and as means of communication. The intellectual development course gives the human an abstract and practical intelligence.

Catch Up Numeracy Programme. This is used as intervention of learners with learning disabilities in grasping numerical skills in many schools in the United Kingdom (UK) and it is done on a face-to-face basis. The initial intervention strategies are made up of ten components with twenty-two detailed assessments (Dowker, 2004). Any intervention should start with thorough competency assessments (Henderson et al. 2003). After the assessment, 15 minutes of structured intervention sessions weekly are provided to the learners.

“Numerical Intelligence” Programme. This programme was developed by several authors (Lucangeli, De Candia, & Poli, 2003) and adapted from Università Degli Studi Di Padova (2014). The program is prepared as a didactic curriculum, but with some specific characteristics. Its focus is not the acquisition of concepts at the base of each mathematical curriculum, but it is intended as a program intended to foster the numerical abilities from the preschool to the fifth-grade level according to the models of numerical intelligence as derived from cognitive developmental science.

Virtual Environment Program. The virtual environment, named “Tom's Rescue”, is an online computer aided instruction to assist children with mathematical disability. It was developed by de Castro, Bissaco, Panccioni, Rodrigues, and Domingues (2014) with the purpose of positive stimulation in reasoning and pedagogically helping children in learning mathematics. This virtual environment has two settings which promote entertainment and mini-games. *“Its storyline was designed for child's interaction and follows a character named Tom. Tom is a small turtle from a community located in a forest near the city who was captured to be sold in an open-air market in the city. Some members of his community are upset at Tom's capture and plan a rescue, which is led by a monkey named Caco. Caco is the avatar.”*

As learners with dyscalculia need special treatment, hence a special mathematics teacher is needed to assist and help the child. Huge classes would not warrant a healthy environment of these learners. Majority of teachers in mathematics may not be aware of this math learning disability and are not trained to do the assessment. Moreover, assessment tools may not be available at hand, or if available, it needs training for the assessor. This situation is a hindrance to improving mathematics achievement in the basic education classes. Early detection of dyscalculia is vital hence, preschool teachers need to be aware of this disorder. (Dias, Pereira, and Borsel, 2013).

The seven studies also convey an important message to mathematics teachers, that mathematics can be taught in a more enjoyable, meaningful and interesting way. Love for mathematics can be developed if the teacher loves to teach the subject. There are many different ways a teacher can do to make the classroom activity enjoyable for the children. Teachers should have the pedagogical competence armed with interesting strategies and techniques in the teaching of mathematics and the personal attributes to commit in helping the learners.

Parents with dyscalculic children need to cooperate with the school in order to come up with better strategies to help the child. They, too, need to know how to help their children.

The Emergent Mathematics Remediation Model for Dyscalculic Children

Based on study findings, the following management model is proposed to assist learners with dyscalculia. The results of the study evolved the following propositions.

Proposition 1. Any intervention for learners with dyscalculia can be effective if done individually.

Butterworth, (2003), Henderson, (2003), and Dowker, (2004) advocated that one-on-one mentoring is necessary for children with dyscalculia because they need focus and continuous assessment. There is a significant impact if individualized work will be given to children with learning disabilities and should not be very large and many to be effective.

Proposition 2. Multisensory and real-life situations can make lessons interesting and meaningful to learners with dyscalculia.

Chinn (2004) suggested variations of methods, strategies, and approaches should be employed. Suggestion is to make use of a multisensory approach in mathematics learning and teaching. And it is necessary to have constant evaluation of the interventions used to identify which strategies and approaches fitted to children and which are not.

Proposition 3. Parents are inevitable in the pursuit of helping their children with dyscalculia

Henderson (2001) suggested that parents of dyscalculic children “should try to understand their child’s learning style, give support using their strengths, and try to stay calm.” Parents, whether educated or not, need to work hand-in-hand with the teachers of their children with dyscalculia. This will motivate teachers to do more for the child because there is external support and somebody who is more concerned for the child. Teachers may have the greatest role in the cognitive development of a child, but for a child with disability, both teacher and parent can assume the same role.

Proposition 4. A remediation program with assessors and specialists can be implemented to assist mathematics teachers improve their students with mathematics disability.

Mundia (2012) suggested a long-term intervention strategies and approaches might be helpful: (a) the usage of informal authentic assessment to evaluate math skills; (b) interventions to address math anxiety and phobia; (c) administrative decisions to adjust math assessment and make them friendly; and (d) improving teacher education through initial and continuous training programs. These are intended to assist a dyscalculic learner to minimize their difficulties during mathematics lessons and tests. They are to be implemented by regular teachers, the school administrators, and teacher educators respectively.

From the above propositions, the schema of the model is shown on Figure 1 showing the relationships of people and processes. A remediation program is expected to succeed if all the four actors are doing their roles. An accurate diagnosis would lead to specific disabilities to be addressed. Parents’ support is inevitable as they know and understand their children better in terms of emotions and behavior. Teachers in the classroom have a very important role to play from the diagnosis to the interventions. Most importantly, the school has to give attention and concern to learners with dyscalculia and to take appropriate actions to help these learners.

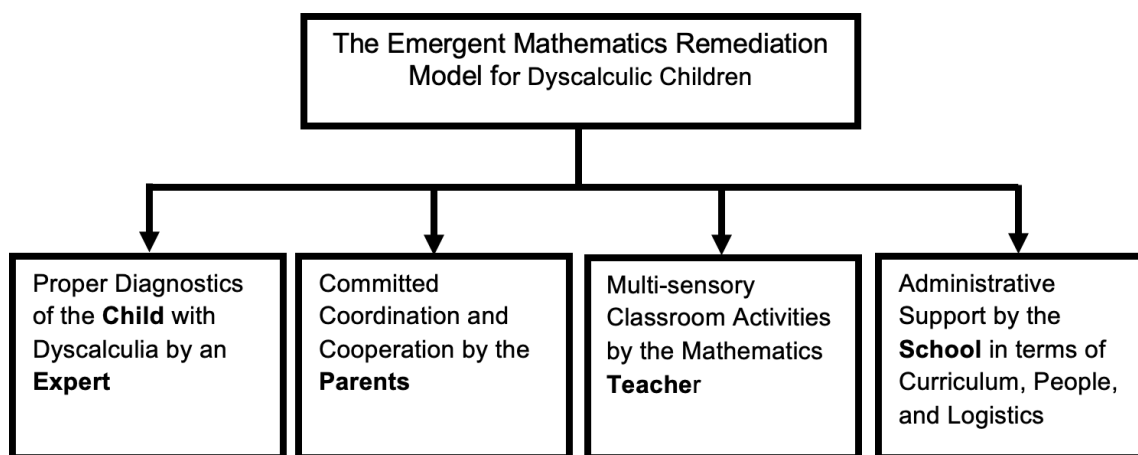


Figure 1. The Emergent Mathematics Remediation Model for Dyscalculic Children

Conclusion

Children with dyscalculia still can cope up with the required mathematics curriculum through interventions and most importantly, cooperative endeavors of the parent, teacher, and school. A child with dyscalculia still has hope to succeed in life

Recommendations

Based on the findings and the model, the following recommendations are suggested:

1. Training of mathematics teachers so that they will be aware of dyscalculic students in their classes, how to assess them properly and what should be done initially.
2. Schools may avail of assessment tools to detect dyscalculia and designate a focal person to handle the assessment.
3. The school may design a mathematics remedial program for dyscalculic students to start the intervention right after the assessment
4. Parents may also have their awareness sessions and trainings that would encourage them to be more involved in the monitoring.
5. The school may decide on what appropriate intervention program based on the model on “*The Mathematics Remediation Program for Dyscalculic Children*”.

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