

An intervention study with children having mathematics learning difficulties with and without comorbid reading difficulties

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In this paper I will be presenting the theoretical framework and research methods I have used to collect the data for my PhD study. The study focused on finding effective strategies for helping children struggling with mathematics. The project was carried out with boys in Grade 5 (9 - 10 years old). To identify the learners for the main part of the study a battery of eight assessments was used including standardised tests for numeracy, reading and Intelligence Quotient (IQ). Three children were identified as having mathematics learning difficulties only and three with comorbid difficulties in mathematics and reading. The selected participants then followed an intervention programme based on the *Catch Up Numeracy* intervention programme. Post-assessment followed to determine whether any progress was made by the learners.

Keywords: Mathematics Learning Difficulties (MLD), primary, intervention strategies, research methods, Vygotsky

Introduction

Studies about reading difficulties (RD) are far more numerous than those about Mathematics Learning Difficulties (MLD) (Desoete, Roeyers & De Clercq, 2004). This is of great concern when one considers the importance of mathematics during school life and beyond. A study carried out by Bynner and Parsons (2000) illustrated that adults having MLD were more likely to be unemployed than other adults who only exhibited literacy difficulties. As a result more studies about MLD are needed especially in the field of intervention strategies so that individuals with MLD may be supported to overcome their barriers in mathematics learning from an early age. In Malta very little research has taken place about MLD. Additionally no appropriate specific intervention programme is in place for these learners in most schools. Through my research I wish to contribute to the body of knowledge currently available internationally and to that available locally.

Research aims

This research aims to explore which strategies are useful with children having MLD and therefore which kind of intervention, if any, would help learners struggling with mathematics to overcome their difficulties. It also aims to look into the relationship between MLD and RD and to understand better whether the numeracy difficulties encountered by children with solely MLD are similar to or diverse from those experienced by children who have MLD only. The study also aims to focus on the nature and degree of the MLD displayed by each individual learner. The framework of my research will also seek to find answers to subsidiary questions. I intend to find out whether the children assessed with MLD or both MLD and RD and also with a profile of dyscalculia by the Screener (Butterworth, 2003) have difficulties in specific numeracy components or in a few. I also hope to understand whether mathematics anxiety is one of the difficulties experienced by the learners in the study.

Literature review

Human beings are born with the ability “to respond to the numerical properties of their visual world, without benefit of language, abstract reasoning, or much opportunity to manipulate their world” (Butterworth, 2005, p.5). Research has in fact illustrated how infants are equipped with several domain-specific mechanisms such as that of ‘number sense’ which allow them to perceive and understand quantities in an intuitive manner (Dehaene, 2009; Starkey & Cooper, 1980). As outlined by Emerson and Babbie (2010) “number sense underlies the ability to make sense of number relationships, patterns within and between numbers, and the way numbers are built from other numbers” (p. 4). A longitudinal study carried out by Geary et al. (2009) illustrated that whether an individual understands the numerosity of a set is one of two of the main predictors of low achievement in mathematics.

Defining terms used

Although research about MLD has been given increased importance in recent years, no universal definition has yet been agreed upon for this construct. For the purpose of my study I chose to give a specific construct to each of the terms used. I used the term *Mathematics Learning Difficulties* (MLD) to refer to all the individuals who underachieve in mathematics no matter what the underlying cause may be. As suggested by Dowker (2005) terms like ‘difficulties with arithmetic’, ‘mathematics and numeracy’ have been used in a more generic sense to denote all “children or adults who struggle or fail to cope with some of the aspects of arithmetic that are necessary or desirable for educational or practical purposes” (p.11). I therefore opted to make use of this term because in my study poor achievement serves as a primary criterion for classifying the main participants in this study. Additionally, since I acknowledge that arithmetic is a complex ability made up of a wide spectrum of skills (Dowker, *ibid.*), I have also chosen this term because research has suggested that the group of learners with MLD is likely to constitute a heterogeneous group of subjects (Bartelet, Ansari, Vaessen & Blomert, 2014) which is the case if MLD refers to all those learners who underachieve in mathematics. On the contrary I chose to use the term ‘dyscalculia’ to refer to a specific learning difficulty in mathematics and to be only one of the causes of MLD. This corroborates contemporary research which seems to conjecture that some of the causes of dyscalculia include an inability to understand the numerosity of a set (Geary et al., 2009) and a nemesis in approximate number tasks normally referred to as the Approximate Number System (ANS) (Piazza, Pinel, Le Bihan & Dehaene, 2007). Dyscalculia may be caused neurobiologically and therefore is possibly a genetic inherited condition as indicated by studies such as that by Ansari and Karmiloff-Smith (2002).

Identifying and assessing for MLD

Identifying learners with MLD is not an easy task. The ways in which different studies make use of cut-off scores to define the term Mathematical Learning Difficulties (MLD) vary noticeably. However in this study the term MLD was taken to indicate all those pupils who fall below a cut-off point of approximately the 35th percentile. Studies use this cut-off point to identify pupils who are underachieving in mathematics due to dissimilar potential causes without necessarily having biological inherited weaknesses in mathematical cognition (Jordan, Kaplan, Olah & Locuniak, 2006). This cut-off point allowed me to study a larger population of learners who are

struggling with mathematics. Since the rationale of this research project does not involve setting identification criteria for both groups but revolves around finding effective strategies to remediate for individual weaknesses in mathematics learning, even if these are not of a biological nature, taking this broader construct is plausible. Moreover since no clear distinction is yet available between MLD and dyscalculia it was deemed appropriate to take this wider perspective rather than focus on a fine line which has yet not been well defined.

Theoretical Framework

I chose to use Vygotsky's perspectives on development and learning as a structural framework for my study. Vygotsky's theory of cultural mediation underlies my use of an intervention programme to support learners with MLD since it emphasises that a child's development is highly influenced by their culture and social interaction. The programme thus sought to provide these subjects with meaningful interactions which would help them to master specific skills. In my data analysis I intend to seek situations in which the interactions provided by the programme would have allowed the learners to gain specific knowledge that they would have otherwise not gained. Additionally I will seek to identify how such situations would have supported these children in internalising the knowledge presented. This internalisation will take place through the use of what Vygotsky names as "cultural tools". These tools will support the process of signification which Vygotsky sees as the process of attaching meaning to symbols. In my programme I used and will analyse the use of tools including those of language, visual aids, manipulatives, non-verbal gestures and number language. The central role of language will be highlighted by analyzing situations in which this served as a tool to guide the learner to their potential zone of development. As described by Vygotsky (1978) himself, "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers" (p. 86). My analysis will thus seek to illustrate the instances where this interaction was witness to such development.

Research Methods

Although both quantitative and qualitative research methods were used for the collection of data, the main phase of the study was essentially qualitative. The ontological questions and epistemological assumptions of the constructivist paradigm seemed to me most compatible to the nature of my study. Primarily, since MLD is socially constructed, as it is perceived in different ways by different people, this fits the ontological questions asking about the nature of reality which constructivism promotes which is that researchers "do not find or discover knowledge so much as construct and make it" (Schwandt, 1994, p. 125). Additionally, one of the epistemological assumptions of this paradigm indicates that the researcher is in a constant interpersonal relationship with the participant and that they influence each other. This is true in the qualitative phase of my research as the constructivist researcher "opts for a more personal, interactive mode of data collection" (Mertens, 1998, p. 13). Lastly, the constructivist paradigm "is characterized by a concern for the individual" (Cohen, Manion & Morrison, 2007, p. 21). This in my research because my main concern is the well-being of children with MLD and providing such children with a *quality education* as promoted by the Maltese National Minimum Curriculum (NMC) (Ministry of Education, 1999).

The participants for the main phase of the study were students at the boys' school where I teach who were in Grade 5 (9 to 10 years old). My aim was to identify six children struggling with mathematics learning to carry out case studies with each, 3 students with MLD only and 3 with both MLD and RD. The term 'case study' is a generic term used for the investigation of an individual group or phenomenon (Sturman, 1994). Through my research I wish to shed more light on particular issues related to MLD and appropriate intervention and to provide fruitful conclusions as "each case study is unique, but not so unique that we cannot learn from it and apply its lessons more generally" (Wolcott, 1995, p. 175).

The first phase of this research project involved finding norms for assessments which would then be used with the learners intended to participate during the main part of the project. Since no tests for numeracy and reading had been standardized in Malta, I had to find my own norms which would then allow me to identify the main subjects of the study. I began by selecting a numeracy standardised test which would be suitable for Malta. I primarily piloted three tests with 10 pupils. All ten pupils sat the Basic Number Screening Test (Hodder Education, 2001) (Test A). Five of the same participants also sat Chinn's (2012) assessment (Test B) whilst the other five sat Progress in Maths (Clausen-May, Vappula & Ruddock, 2009) (Test C). The results from all three tests were compared. Results were coherent as pupils assessed with a profile of MLD by one test were also assessed with the same difficulties in the other test. However, it was observed that Test C took up much more time to administer and had a lot of written instructions. Since my main objective was to assess numeracy skills I decided not to use this test any further fearing that the pupils' reading and writing skills would obscure the final assessment. So I decided to use Test A and Test B.

As indicated by Test A, instructions were read out orally to the participants thus reducing the impact which pupils' reading skills may have. However although in Malta mathematics is taught through a second language, English, I decided that it would be best to translate the instructions to Maltese (the mother tongue of most learners) to ensure that learners' understanding would also not impinge on their attainment in the tests. When changes were made, the tests were piloted again. Test A was administered reading the instructions in both Maltese and English. Test B was also re-administered but in its original form. Results were coherent. Both tests were then used for the main phase of this first part. Norms thus needed to be found by administering the tests to a larger cohort of learners. Consequently, Test A and Test B together with the reading assessment, the Single Word Reading Test (Foster, 2007), were finally carried out with half the population of students in all the Church schools for boys in Malta. Results were analysed statistically and norms were extrapolated.

The main phase of the research study commenced by assessing the 50 students at the school where I teach using Test A and Test B. The participants of the main phase of the study were selected by identifying those individuals who performed within the 35th percentile in both tests and were therefore probably struggling with mathematics. My choice of participants was also discussed with the students' classroom teachers to see whether they confirmed the results. The chosen participants were then also asked to do a reading assessment (Single Word Reading Test – Foster, 2007) and the English and Maltese comprehension test (Firman, Martinelli, Camilleri & Ventura, 2010). Once the participants were chosen as three having MLD and three with MLD and RD they sat for an IQ test, a test for dyspraxia and the Dyscalculia Screener (Butterworth, 2003). Since one of the participants was identified as having an above average IQ with his learning difficulties were mostly due to social

difficulties, he was replaced by another participant who fitted the required criteria to reduce variables. The six participants primarily sat for the *Catch Up Numeracy* (Catch Up, 2009) formative assessment. They were then given a total of 20 intervention sessions each spread over six months. The sessions were based on the framework provided by Catch Up and each included a review phase, a new activity and a linked recording section which would serve as formative assessment for what the child would have learned. During this phase of the study, interviews were carried out with the class teacher, Learning Support Assistant (LSA) where applicable and the parents of each child. After the intervention phase Catch Up's formative assessment was re-administered. The participants were also re-assessed using Test A and Test B to see whether any improvements could be recorded. An informal interview was carried out with the children at the end of the programme to have a view of their perspectives of how beneficial the programme was and to identify whether they felt that any changes could be done.

Future Targets

The preliminary analysis of the data has shown that the children did make a marked improvement in the numeracy components assessed and intervened upon. I now hope to analyse the different strategies which have facilitated this improvement to present them in future work. This analysis will be done using Vygotsky's theoretical framework and will seek to provide some insights into whether the strategies effective with children having MLD only are as effective with children having MLD and RD as determined by my original research aims and questions.

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