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Dyscalculia And Development Of Sense Of Number: Implementation Of An Intervention Program

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A B S T R A C T

The present study try to understand how the application of a Dyscalculus Intervention Program, focused at the development of number sense, influences the mathematical performance of children in the 2nd year of schooling. We performed an evaluation of the mathematical competences of a group of students, of the 2nd year of schooling, and identified possible signs of dyscalculia through an exhaustive documentary analysis and, also, the resolution of a Mathematical Competence Check Test. After identifying the subjects with dyscalculia we applied a program oriented to the development of mathematical competences. The results indicate that the activities performed were very positive, contributing to the improvement of most of the skills evaluated and directed to the number sense, namely: establish numerical orders / sequences, compare and order numbers, perform arithmetic operations (additions and subtractions) and solve simple problems using the operations that best suit the type of question. Given the type of study we consider relevant the testing of the method to other participants.

Keywords: Dyscalculia, Sense Of Number, Intervention Program.

INTRODUCTION

Mathematical learning difficulties may result from difficulties in one or more domains of mathematics - arithmetic, algebra and geometry - but also because there is a varied set of cognitive deficits that may contribute to their emergence(Fritz, Haase, & Räsänen, 2019; Geary, Hamson, & Hoard, 2000; Karagiannakis, Baccaglini-Frank, & Papadatos, 2014).

The dyscalculia arises mainly in children, has an evolutionary character and translates the difficulties in the acquisition and the development of arithmetic notions, which, in turn, manifest themselves in great difficulties in calculus operations(Berch & Mazzocco, 2007; Rebelo, 1998). Dyscalculia affects language and may be associated with one or more of the three mathematical domains. However, the acquisition of the first domain (arithmetic) is considered more relevant, since it can be interpreted as a system of language similar to reading, which instead of letters uses numerical symbols.

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The difficulties of the discalculic students are framed in the various processing factors of the information involved in mathematics identifying: attention deficits, visual-spatial deficits; auditory processing difficulties; memory problems; motor difficulties; difficulties in cognitive and metacognitive processes(Cruz, 2009; Moreau, Wiebels, Wilson, & Waldie, 2019).

AmericanPsychiatricAssociation (2013) in DSM-5 describes dyscalculia as a Specific Learning Disorder with impairment in Mathematics and refers to a pattern of difficulties characterized essentially by problems in the processing of numerical information (in particular in the sense of number), learning of arithmetic facts and accurate and fluent calculations, and can be assessed as severe, moderate, or mild, depending on the degree of difficulty the student presents and the domains it affects.

For the diagnosis of dyscalculia, standard performance tests, usually supplemented with intelligence tests(Geary et al., 2000; Kaufmann & von Aster, 2012).

According to Bernardi and Stobäus (2011), many people with dyscalculia can become mathematically competent if the problem is diagnosed in a timely and the intervention well-structured. Reeducation and the prevention of dyscalculia require, first and foremost, changes in approaches to teaching and instruction. The modification and adjustment of practices to individual differences favor not only the developmental capacities but also the intrinsic motivation of the students(Ribeiro & Baptista, 2006).

For many researchers, number sense is the engine of students' mathematical competence development(McIntosh, Reys, & Reys, 1992; NationalCouncilOfTeachersOfMathematics, 2007; D. Yang, 2003). According to the National Council of Teachers of Mathematics (NationalCouncilOfTeachersOfMathematics, 2007), number sense is indeed the "key point" of mathematics education in the early years, and its teaching should begin as early as possible (D. C. Yang & Li, 2008).

The National Council of Teachers (USA, 1989) identified five components that characterize number sense: number meaning, number relationships, number magnitude, operations involving numbers and referents for numbers and quantities. These skills are considered important because they contribute to general intuitions about numbers and lay the foundation for more advanced skills.

Greeno (1991), argues that the sense of number must develop through tasks with varied contexts that lead students to discover how numbers are related, thus promoting the processes of resolution and the effectiveness of their calculations .

It is at the beginning of the school process that students make fundamental acquisitions, which serve as a basis for later learning, namely the acquisition of the number sense, key to all mathematical learning, the need arises to understand how the implementation of a program aimed at the development of number sense will contribute to the improvement of the mathematical performance of children with signs of dyscalculia.

In parallel, specific objectives were outlined:

- Evaluate the mathematical skills of a group of children;

- Identify evidence of dyscalculia through the application of the Mathematical Competence Check test;

- Adapt and implement an intervention program in the development of number sense.

METHODOLOGY

This study was based on a qualitative, descriptive and interpretive approach(Bogdan & Biklen, 1994), complemented by action research, in which researchers were active participants (Sanches, 2005).

As instruments we use the Competency Checklist, based on the information processing factors pointed out by Miller & Mercer (1997); the Dyscalculia Evidence Checklist, built through the Program and Curricular Targets of Mathematics of Basic Education (Bivar, Grosso, Oliveira, & Timóteo, 2013), made available by the General Directorate of Education; and the Mathematical Competence Verification Test with its application manual and correction criteria (Harp, 2011). We proceeded according to Guillemin, Bombardier, and Beaton (1993) and submitted the Mathematical Competence Verification test to the international rules of translation and cultural adaptation to the target language: 1- initial translation; 2- synthesis of translation; 3- back-translation and 4- evaluation by specialists (2 Ph.D. professors in Special Education and a PhD in Educational Psychology).

In the case of the remaining instruments, no translation was necessary, but we proceeded to the adaptation and evaluation by specialists (2 PhD Special Education Doctors and a PhD in Educational Psychology).

Participants were selected for convenience in the Santarém School Group, and a group of the second year of schooling with a higher percentage of failure. A documentary analysis was carried out on the processes of the 23 students and we accessed the evaluation records made by the class teacher. This procedure provided us with important answers to the completion of the Dysalculia Evidence Checklist, which was complemented with the information collected from the class teacher. Then, the Mathematical Competence Check Test (pre-test) was applied to all students in the class, in two 45-minute sessions, given their length.

This test was built based on the specific characteristics of the dyscalculia, and each one of the 16 questions that compose it is directed to the evaluation of certain competences that, normally, are not properly developed in the discalculic students: 1) differentiate numbers; 2) identify sets; 3) establish one-to-one correspondence; 4) establish numerical orders / sequences; 5) identify numbers (visually); 6) graphically identify numbers through auditory information; 7) understand the meaning of numbers; 8) compare numbers, establish a numerical order, write in small spaces; 9) compare numbers; 10) understand the meaning of the signs; 11) realize arithmetic operations, organize the space of the worksheet; 12) understand the directional aspects that involve orientations; 13) judging the size of objects; 14) organize events in time; 15) understand the passage of time; and 16) use the operations that best suit the type of problem, perform arithmetic operations, organize sheet space.

After the application of the test and its intersection with the information obtained in the checklists, it was possible to select the five students who participated in the study. We verified that four of the students have the projectable age for the year of schooling (eight years) and one is nine years old, since it was repeating the second year.

After these procedures, an intervention plan was drawn, composed of six sessions of 90 minutes, with a set of progressively more complex mathematical activities. This plan was applied to the class, but was specifically addressed to the selected students, who were assigned a letter (A, B, C, D, E) (Table 1).

Table 1. Schedule of intervention sessions

Session	Date	Hour	Summary
1	10/05/2017	14h30-16h00	Numbers up to 10: counts, comparisons, reading and writing numbers, number decomposition
2	17/05/2017	14h30-16h00	Numbers up to 20: counting, comparing, reading and writing numbers, number decomposition.
3	24/05/2017	14h30-16h00	Numbers up to 100: counting, comparing, reading and writing numbers, number decomposition.
4	31/05/2017	14h30-16h00	Numbers up to 1000: counting, comparing, reading and writing numbers, number decomposition.
5	07/06/2017	14h30-16h00	Counts, comparisons, reading and writing of numbers, number decomposition. Additions and subtractions using the decomposition and the numerical line.
6	14/06/2017	14h30-16h00	Counts, comparisons, reading and writing of numbers, number decomposition. Additions and subtractions using the decomposition and the numerical line.

For each session, a plan was organized, describing, in detail, the activities developed with the students and the objectives intended in each session. After the first session, all the rest began with a cumulative review of the content covered in the previous sessions and in all of them, teaching material was available at the school, in particular the cuisenaire bars, since they were a manipulative material especially suited for the acquisition numerical skills. With the increase in the complexity of the contents, the multibasic material was also used, due to the similarities with the cuisenaire bars. At the end of each session, were given to the students a record and consolidation of the learning process and a Session Assessment Form. After all the interventions, the post-test was applied.

RESULT

Through the completion of the Skills Checklists, it was possible to signal five students who presented a low percentage of acquisition of the expected competences for the year of schooling they attend, having already registered gaps in learning the contents of the previous year (Table 2).

Table 2. Skills Checklist

Skills Subjects	1st year			2. year *		
	Yes	No	Sometimes	Yes	No	Sometimes
A	30,76%	7,79%	61,53%	10%	0%	80%
B	7,69%	53,84%	38,46%	0%	50%	40%
C	23,07%	23,07%	53,84%	10%	50%	30%
D	46,15%	53,84%	0%	30%	20%	40
E	7,69%	30,76%	61,53%	0%	40%	50%

After application to the class of the Dysalculia Evidence Checklist, it was possible to verify a high percentage of crucial dyscalculia symptoms, namely difficulties in keeping attention oriented to the different stages of the algorithms or problem solving; difficulties in differentiating numbers or symbols from operations; difficulties in the directional aspects of mathematics, which involve top-down, left-right orientations, and number alignment; difficulties in counting according to a sequence; difficulty in remembering the procedures of an algorithm; difficulties in identifying the hours and understanding the passage of time; difficulties in writing numbers in small spaces; difficulties in organizing information; difficulties in monitoring problem solving processes; and difficulties in generalizing strategies for appropriate situations.

The pre-test provided us with some of the difficulties presented by the students. Based on the results obtained, the lowest percentages (three of them lower than 50%) coincided with the subjects already signaled through the information obtained in both checklists, which allowed to confirm the selection of participants who participated on this research (Table 3).

Table 3. Pretest Results

Items	Student	A	B	C	D	E
1	4	4	2	4	4	4
2	2	2	2	2	2	2
3	4	4	4	0	4	0
4	16	1	4	5	5	0
5	6	6	6	6	6	6
6	6	2	0	6	6	6
7	3	2	2	3	3	3
8	6	0	0	0	0	0
	1	1	0	0	0	0
9	10	2	2	6	10	6
10	6	2	1	4	2	1
11	6	0	1.75	3.6	1.2	0
	1	0	1	1	0	0
12	4	1	4	4	4	2
13	2	2	2	2	1	2
14	2	0	0	0	0	0
15	6	0	3	6	6	1
16.1	3	0	0	3	3	1.5
	2	0	0	0	2	0
	1	0	1	1	1	1
16.2	3	0	0	0.5	0.5	0
	2	0	0	0	1	0
	1	0	1	1	0	1
16.3	3	0	0	0	0	1.5
	2	0	0	0	0	0
	1	0	1	1	1	1
TOTAL	100%	29%	37.75%	59.10%	62.70%	39%

During the sessions of the Program of Intervention in Dyscalculia data were collected in the observations made and in the evaluation of the sessions by the students (Table 4).

Table 4. Post-Test Result

Items	Student	A	B	C	D	E
1	4	4	4	4	4	4
2	2	2	2	2	2	2
3	4	4	4	4	4	0
4	15	13	15	15	13	13
5	6	6	6	6	6	6
6	6	2	2	6	6	6
7	3	3	3	3	7	3
8	5	5	0	5	5	5
	1	1	0	1	1	0
9	10	6	3	6	6	10
10	6	4	3	4	6	4
11	6	4.5	4.5	5.25	6	0
	1	1	1	1	1	0
12	4	4	4	4	4	4
13	2	2	2	2	2	2
14	2	0	0	0	2	2
15	5	2.5	4	5	4	4

Items	Student	A	B	C	D	E
16.1	3	3	3	3	3	3
	2	3	0	0	2	3
	1	1	1	1	1	1
16.2	3	3	3	3	35	3
	2	0	0	1	2	0
	1	1	1	1	1	1
16.3	3	1.5	1.5	1.5	3	1.5
	2	25	0	1	2	0
	1	1	1	1	1	1
TOTAL	100%	82%	74%	90.25%	93%	78.5%

Through the observations made, it was found that, although Student A did not always make pertinent interventions, he participated actively in all sessions.

There was an improvement in the ability to graph numbers (through auditory information), to compare numbers and to write them in descending order, to perform arithmetic operations, to understand the directional aspects involving orientations, and to use the operations that best the type of problem. However, there are still significant difficulties in organizing events in time and understanding of the passage of time, as well as errors in the accomplishment of arithmetic operations. As far as Student B is concerned, there was a considerable level of anxiety and nervousness about mathematics.

Still, the program was very positive for the student, who improved the ability to differentiate numbers, establish numerical orders / sequences, and perform arithmetic operations (additions and subtractions). However, although there are improvements, there are still difficulties in graphical representation of numbers through auditory information, in the comparison of numbers and writing of numbers in descending order, in understanding the meaning of mathematical signs / symbols and in the use of the operations that best fit the type of problem. With regard to Student C, although something inattentive and sometimes unsafe, he has always shown a great deal of interest in the proposed activities.

Their positive performance during the sessions was, in turn, reflected in the post-test result, where improvement in one-to-one matching skills, establishment of numerical orders / sequences, comparison of numbers, and writing was evident them in descending order and to use the operations that best suit the type of problem. There are still difficulties in the organization of events in time. Alumni D was the one that presented a better performance during the six sessions of the program.

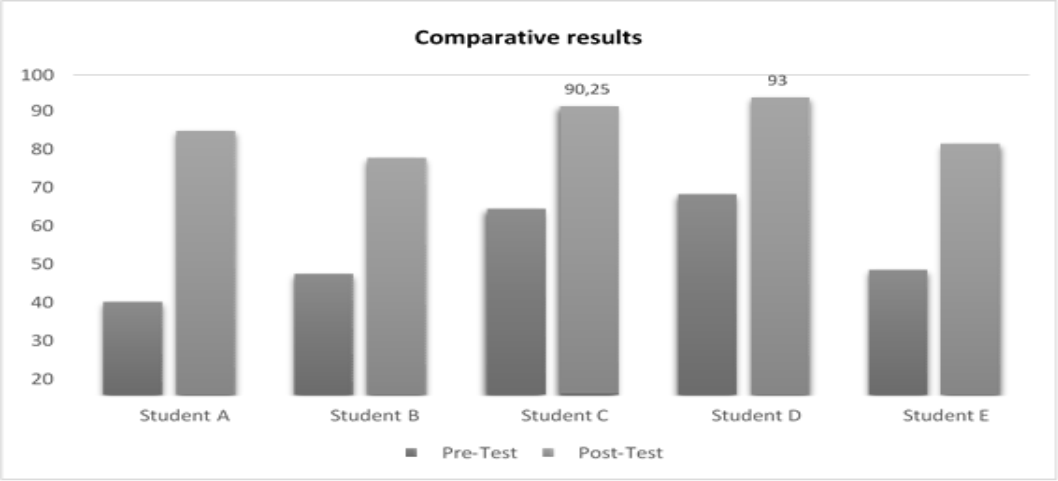
Their very positive performance, both in the construction of knowledge, as well as behavior and attitudes, had repercussions on the result obtained in the post-test, where there were improvements in the competences to establish numerical orders / sequences, to compare numbers and to write them in descending order, to perform arithmetic operations (additions and subtractions), to organize events in time and to use the operations that best suit the type of problem. With regard to Student E, this was little participative in the accomplishment of the proposed tasks and extremely deconcentrated.

In spite of the above, there has been progress in competencies for one-to-one correspondence, numerical ordering / sequencing, to understand the directional aspects involving orientations, to organize events in time, and to understand the passage of time, and to use the arithmetic operations that best suit the type of problem.

It should also be noted that although all participants have improved their ability to use the operations that best fit the type of problem, only Student D has been able to solve problems with more than one step. The remaining students only solved some of the problem by excluding one of the steps required to find the correct result.

After completing the program, the five participants performed the post-test and a comparative analysis was performed between the pre- and post-test (Graphic 1).

Graphic 1



Overall, it was found that Student A had the most significant improvement, of 53.5%. Student D had the highest absolute performance but with a less significant improvement of 30.3%.

The results of the post-test were, in general, very positive in all students, with the increase in the percentages obtained in questions 4, 8, 11 and 16 of the post-test, which reflects an improvement in the competences to establish orders / numerical sequences, to compare and order numbers, to perform arithmetic operations (additions and subtractions) and to solve simple problems with just one step using the operations that best suit the type of question.

CONCLUSION

It was our goal to construct and implement a intervention program of dyscalculia, oriented towards the development of number sense which, according to the literature, is the basis of mathematical learning.

Based on the results obtained, it was concluded that the Dyscalculia Intervention Program was very positive and beneficial for the development of some students' mathematical skills. The applied program focused fundamentally on the development of competences oriented towards number sense. By the percentages resulting in the post-test, it is found that the issues where there was a more significant improvement are precisely those where a relatively well-developed number sense is required: counting, sequencing, sorting, decomposition.

Through the activities carried out it was also possible to verify that the mathematical learning aimed at the development of number sense are essential since they contribute not only to the improvement of the abilities to solve daily problems, but also to promote the students' cognitive development.

On the other hand, the program had little influence on the results in the understanding and organization of the passage of time, since the sessions were directed only to the development of competences related to number sense. Therefore, a program of this nature is not enough to overcome the difficulties in this area, since it is known that the structuring of space and time are significantly influenced by the level of psychomotor development of children.

However, knowing that psychomotor factors significantly influence learning and that the psychomotor profile of the participants of the present study were not identified, nor the instruments constructed and applied, then the results, although very positive, are not generalizable.

According to the results obtained, the contribution of this study to the students' learning in some mathematical contents was well-known. Thus, it would be interesting that in future projects other activities directed to other domains of arithmetic, geometry and, not least, for psychomotricity should be included.

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