

Chapter # 39

SCREENING FOR MATHEMATICAL DIFFICULTIES: ELABORATION AND PILOT STUDY

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ABSTRACT

In Brazil, there are few studies about identification and early intervention of difficulties in mathematics. Objectives: To develop a screening tool to identify students at risk for mathematical difficulties in the initial literacy series and to verify the applicability of the screening elaborated. Methods: From a bibliographic survey, 8 mathematical skills were selected based on the Triple Code Model to elaborate a screening program composed of number sense, number line, place value, addition, subtraction, multiplication, division and problem-solving skills. The screening was applied in four 45-minute sessions, twice a week, during class time. A total of 201 students from the 1st and 2nd grades of elementary school were evaluated. Of these, 44 students were identified as at risk and referred to the remediation program. The study showed the need to reduce the number of skills to 5: number sense, number line, place value, addition and subtraction. This reduction occurred due to the observation that knowledge related to addition and subtraction should be developed first. Conclusion: The adjustments made based on the results of the pilot study will favor the application of the screening to better identify students with difficulties in mathematical skills.

Keywords: learning, screening, skills, mathematical skills.

1. INTRODUCTION

Every student need and deserves to have knowledge, comprehension and competency to be able to acquire mathematical learning. However, many students show difficulties in mathematical learning according to data presented in the Results Report of National System of Basic Education Evaluation (SAEB) in 2019 (National Institution of Study and Educational Research Anísio Teixeira, 2023; Powell & Fuchs, 2015).

The early identification of these mathematical difficulties may detect students who need educational support or intervention before the learning difficulties occur (Jordan, Kaplan, Locuniak, & Ramineni, 2007). This early identification can be done through a diagnostic of mathematical skills which helps teachers identify the strong and weak points in students and the comprehension of these weaknesses enables teachers to identify and adjust one or more intervention programs that address the difficulties the student presents (Powell & Fuchs, 2015).

Those difficulties may involve one or more areas in Mathematics due to cognitive deficits, inadequate instructions, or a combination of factors (Geary, 2004). Studies have shown that students participating in high quality preventive programs have obtained positive impacts in development and these benefits extend to academic, sociability and employability aspects (Carneiro & Heckman, 2003; Butterworth, 2005).

One of the most cited preventive programs in literature is the Response to Intervention Model (RTI) which also provides early interventions in levels to students at risk of academic

failure (Fuchs & Fuchs, 2006). The RTI model is a multi-tiered system, divided in 3 levels, or three tier: Tier 1 is a universal screening of difficulties in students, and it is performed by everyone in the classroom. Tier 2 is composed by students that showed low performance in Level 1, identified as students at risk for academic learning and in this tier, they start receiving specific, progressive and effective interventions in small groups giving the students the opportunity to develop academic knowledge. Level 3 is for students who don't respond to the intervention in level 2 and need an individual intervention, this time in clinical context, and the risk being confirmed, they are referred to an interdisciplinary team for the confirmation or exclusion of the diagnostic (Andrade, Andrade & Capellini, 2014; Fuchs & Fuchs, 2006).

Therefore, this study is justified by the fact that there is still a gap in studies regarding the response to intervention program with mathematical skills in Brazil, as well as the lack of effective instruments for identification and intervention in students at risk of problems in mathematical learning. This way, the objective of this study was to elaborate a screening program to identify difficulties in mathematical skills in students in early school grades and verify the applicability of a study pilot.

2. BACKGROUND

There is an increasing concern about an early identification of students at risk of difficulties in mathematics in the early years. It is important to identify the predictors of these mathematical difficulties in students so that an early intervention, focusing on these characteristics could be possible. Based on current studies on the predictors of mathematical difficulties, it is now possible to develop early interventions for learning mathematics to prevent and remediate these students at risk of mathematical difficulties (Bryant, Bryant, Gersten, Scammacca & Chavez, 2008a)

To identify these at-risk students, the strategy would be to evaluate all students in the classroom in a screening that shows students who perform below their peers. Once these at-risk students have been identified, they will be selected to participate in tier 2, with evidence-based interventions to prevent these mathematical difficulties (Andrade et al., 2014; Fuchs & Fuchs, 2006). With the premise of identifying these students with learning difficulties, based on screening, with a response to educational intervention inferior to their peers, the RTI differentiates inferior performance by the quality of teaching and the risk of difficulty. If the student presents difficulty in teaching that benefits most of other students, then the problem is not in the quality of teaching but in the difficulties of the student himself (Fuchs et al, 2005). The student at risk is identified based on his/her lack of response to various interventions in educational contexts, and no longer as discrepancies between academic performance and intellectual capacity, but rather by the lack of progress in response to appropriate interventions (Fuchs et al, 2005; Fuchs & Fuchs, 2006)

The RTI, in tier 1, makes it possible to identify students at risk for learning difficulties, considering the risk of dyslexia, dyscalculia and behavioral problems, which do not yet have neurological maturity and have not had adequate opportunities for intervention, as recommended in the Diagnostic and statistical manual of mental disorders (American Psychiatric Association, 2022). These students require preventive interventions before the onset of a greater academic difficulty, providing adequate learning development and academic success (Fuchs et al, 2007b). Screening, Tier 1, focuses on universal design, which should include effective, evidence-based instruction that benefits all students, to identify students at risk for mathematics difficulties (Bryant et al., 2008a; Bryant et al., 2008b; Fuchs & Fuchs, 2006).

In Brazil, the experience with RTI has proven effective in identifying students at risk for dyslexia, with programs focusing on the first layer, tutoring the teachers (Fukuda & Capellini, 2018), the second layer (Andrade et al., 2014; Margutti, Cerqueira-César, & Capellini, 2021) and the third layer (Cerqueira Cesar, Germano, & Capellini, 2018). Also in Brazil, a program was developed with the RTI model for attentional skills, focusing on the three layers (Kerges-Alcantara, Germano, Sillankorva, & Capellini, 2021). Therefore, there was a need to expand studies with the model for mathematical skills, which we are reporting in this chapter.

Studies have shown that basic math skills such as number sense, number lines, place value, addition, subtraction, multiplication, division, and problem solving are predictors of math difficulties (Bryant et al., 2008a; Bryant et al., 2008b; Fuchs, Fuchs, & Hollenbeck, 2007a; Fuchs et al. 2007b; Jordan et al., 2007). Currently, studies such as those by Fuchs et al. (2007a) and Fuchs et al., (2007b) have demonstrated the use of RTI to identify students at risk for mathematics learning.

Some studies demonstrate how tier 1 can identify students at risk for mathematical difficulties and that those referred to Tier 2 interventions can improve their performance in mathematical learning. (Fuchs, et.al 2007a; Powell & Fuchs, 2015). Fuchs et al, (2007a) evaluated, tier 1, through a battery of mathematical assessments, students from 41 first-grade classes, allowing the identification of students at risk for mathematical difficulties based on low performance in the assessment.

Bryant et al. (2008a) identified 126 first-grade students and 140 second-grade students at risk for difficulties in mathematics through a screening that involved a battery of tests involving basic mathematical skills. The identified students were referred to level 2 and underwent interventions that involved initial mathematical concepts and skills, demonstrating a significantly greater effect for second-grade students.

Therefore, developing a screening based on scientific evidence that allows the identification of students at risk for mathematical difficulties, makes it possible to include these students in tier 2 of interventions for better performance in mathematics.

3. METHODS

This study was approved by the committee for Ethics in Research of the University of Philosophy and Sciences – FFC/UNESP – Marília – SP (number CAAE 60381922.0.0000.5406 – opinion number 5.690.282). As procedure, bibliographical research was conducted regarding the theoretical basis to elaborate a screening process to identify difficulties in mathematical skills in students in early school grades.

The databases consulted to elaborate the screening were Pubmed/MEDLINE, SciELO and ERIC and the descriptors selected were listed in the vocabulary indexing of Health Sciences Descriptors, in both Portuguese and English languages combining two terms: Response to Intervention” OR “Remedial Teaching” OR “Remedial teachings” OR “Teaching Remedial” OR “Teachings, Remedial”) AND (Math OR Mathematic OR Arithmetic).

The pilot study was carried out with the objective to verify the applicability of the screening elaborated with 201 students from the 1st and 2nd grade level, regularly enrolled at a public school in São Paulo, Brazil. The screening was applied to all students in early school grades, in four 45-minute sessions, twice a week during class period collectively.

3.1. Objective

Develop a screening tool to identify students at risk for mathematical difficulties in the initial literacy series and to verify the applicability of the screening elaborated.

3.2. Results

In Table 1 we can see the skills that composed the protocol for screening difficulties in mathematical skills formed of 8 abilities: number sense, number line, position value, addition, subtraction, multiplication, division, and problem-solving.

The number sense was composed of 11 tasks and each task was composed of 5 activities; the number line, position value and problem-solving skills were composed of 1 task with 5 activities each; addition, subtraction, multiplication, and division tasks were composed of 2 tasks each, with 5 proposed activities.

Table 1.
Distribution of skills, tasks and activities per school grade level.

SKILLS	TASKS	ACTIVITIES	1st year	2nd year
Number Sense	Magnitude	More points, less points,	x	x
	Cardinality	Correct quantity of objects	x	x
	Ordinality	Position of an object in a conjunct	x	x
	Comparison	Difference in a category	x	x
	Length Measurement	Length	x	x
	Volume Measurement	Volume	x	x
	One to One Correspondence	One to One correspondence		
	Estimate	Approximate quantity without counting	x	x
	Image-Symbol Transposition	Image-Symbol	x	x
	Symbol-Image Transposition	Symbol-Image	x	x
	Verbal number	Name Number	x	x
Number Line	Number Sequence	Number Line	x	x
Position Value	Position - Value	Hundred/Ten/Unity		x
Addition	Addition - Concrete	Concrete - Operations	x	x
	Addition - Operations			
Subtraction	Subtraction - Concrete	Concrete - Operations	x	x
	Subtraction - Operations			
Multiplication	Multiplication - Concrete	Concrete - Operations		x
	Multiplication - Operations			
Division	Division - Concrete	Concrete - Operations		x
	Division - Operations			
Problem-Solving	Problem-solving	Problem-solving involving simple addition and subtraction	x	x

For the screening, 201 students from the 1st and 2nd grade level of Elementary School I participated in the screening to identify students at risk for mathematical difficulties. Of these, 44 students were identified as at risk and were referred to the remediation program. The screening was applied in three 45-minute meetings in the classroom.

In relation to the implementation of the pilot study, it was possible to observe that the students did not present any difficulties regarding the instructions, and performed the tasks with good understanding.

The reduction of tasks was necessary due to the fact that the students had not yet developed the concepts of solving word problems, multiplication and division, indicating difficulties for the students in carrying out the tests.

The National Common Curricular Base (BNCC) (Brazil, 2015) recommends that students in the 1st and 2nd grade level of Elementary School have developed knowledge of understanding numbers and calculating basic addition and subtraction facts. However, the participants in the pilot study had difficulty performing calculations, making it necessary to reduce the procedure, avoiding that the students were characterized as false positives.

In this way, the application of the screening protocol revealed the necessity to reduce the number of skills. Therefore, the screening protocol was reformulated, now having 5 tests tasks: number sense (magnitude/verbal/arabic transposition); number line, position value, Addition and subtraction. The protocol reformulation was necessary due to the fact that the multiplication, division and problem-solving tasks required more cognitive and learning demands which the students in early school grades don't master.

The study is beneficial to all children who have difficulty in learning mathematics, particularly in developing competence. Bringing the problem to our awareness should be a long-term process and moving forward with environmental changes in education provides a better performance in Mathematical learning.

4. FUTURE GUIDELINES

The Response to Intervention (RTI) Model is a multi-tiered system, divided into 3 levels, with Tier 1 being a universal screening across the classroom responsible for identifying students at risk for mathematical difficulties and referring them to Tier 2 intervention.

Future studies will be conducted to define a reference standard for the population of this study, making this screening protocol usable for the early identification of difficulties in the development of mathematical skills.

More studies are needed to document other important mathematical skills to examine new screenings that are effective for other school levels.

5. CONCLUSION/DISCUSSION

This study sought to develop a screening tool to identify students in early grades at risk for mathematical difficulties using the Response to Intervention (RTI) Model. The development of phase 1, screening, of the study was based on a literature review in databases of schoolchildren in the initial years of literacy, emphasizing basic skills as predictors of later mathematical difficulties.

For Chard et al. (2005), mathematical difficulties are considered to be the efforts of students to recover and use basic mathematical knowledge. For these researchers, the efficiency of an education is due to the prevention of these difficulties through assessment and intervention measures. These measures can be found in the RTI, which is a multi-tiered, three-tiered model that seeks to prevent learning difficulties and monitor the progress of the student from tier 1, screening, identifying students at risk for mathematical difficulties and referring them to tier 2 of intervention.

According to Bryant et al (2008a) the RTI approach validates important Level 2 math interventions by identifying students at risk for math difficulties, as the evidence-based, multi-tiered intervention prevents math difficulties.

Fuchs and Fuchs (2006) considered the necessity of screening tools with reference standards for early evaluation and identification of students at risk for any type of learning difficulties. According to literature (Andrade et al., 2014; Bryant et.al 2016; Fuchs & Fuchs, 2006), two components are important for choosing a screening to identify difficulties: the

ability to measure the students' responsiveness to instruction and the student's non-responsiveness to the stimuli applied in the screening.

The following are considered basic mathematical skills: number sense, number line, place value, addition, subtraction, multiplication, division and problem solving, and these are important predictors of mathematical difficulties presented by students. Therefore, these skills were part of this study based on tasks proposed in tier 1, screening, for possible identification of students at risk in mathematical learning (Bryant et al., 2008a; Bryant et al., 2008b; Fuchs et al., 2007a; Fuchs et al., 2007b; Geary, et.al. 2009; Jordan et al., 2007)

However, with the application of tier 1 in the pilot study, it was observed that students in the initial phase of literacy in mathematics had not yet mastered the skills of multiplication, division and problem solving, thus requiring their removal from the screening protocol.

In 2005, from a total of 564 first grade students, Fuchs, et.al. (2005) identified 127 students at risk for mathematical difficulties from tier 1, that is, from screening. After identifying the students at risk, they received tier 2 intervention and demonstrated significantly better performance in mathematical learning.

The importance of the screenings is to identify safely, quickly and at a low cost which skills measure the students' performance identifying the risk of learning difficulties, more specifically in this study, the difficulties in developing mathematical skills.

Thus, the results of this study showed that the need for adjustments to the screening protocol for the mathematical difficulties elaborated in this study, based on the results of the pilot study, made the protocol more robust for investigating the mastery of basic knowledge related to addition, subtraction and, thus, capable of identifying students at risk for mathematical learning in early school grades.

The results of these studies allowed us to conclude that it was possible to develop a screening protocol through the Response to Intervention Model (RTI) based on bibliographical research considering the main mathematical skills to identify students in the early school grades at risk of mathematical difficulties, by the way, the need for adjustments to the screening protocol for the mathematical difficulties, based on the results of the pilot study.

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