THE GOLDEN SOROBAN AS A MEDIATING TOOL FOR CONCEPTUAL APPROPRIATION IN INTELLECTUAL DISABILITY

O SOROBAN DOURADO COMO INSTRUMENTO MEDIADOR PARA A APROPRIAÇÃO CONCEITUAL NA DEFICIÊNCIA INTELECTUAL

EL SOROBÁN DE ORO COMO HERRAMIENTA MEDIADORA DE LA APROPIACIÓN CONCEPTUAL EN LA DISCAPACIDAD INTELECTUAL

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ABSTRACT: The present article has the purpose of discussing the use of the didactic material Golden Soroban, developed as a technical production from a PhD research, as an auxiliary tool on the teaching of the soroban use for intellectual disabled students. The validation of this material arised through qualitative research and the action research was the strategy chosen for the study. Eight intellectual disabled students who were attending the Youth and Adult Education Program from a special education school have used the material. The results revealed that the use of the Golden Soroban, on the teaching process, provided the students' comprehension about the structure of soroban, besides their understanding of the principles of the decimal numeration system as the positional value, ten to ten grouping, and the learning of the mathematical concepts related to numbers and operations. Those results highlight the importance of an education that look at the capacity of the disabled students, and not at their limitations, as well as the fact that all people, regardless of any conditions, can learn and develop themselves, as long as they have the necessary conditions for that in the education process.

KEYWORDS: Mathematics education. Intellectual disability. Soroban. Learning.

RESUMO*: Este artigo tem o objetivo de discutir a utilização do material didático Soroban Dourado, desenvolvido como produção técnica de uma pesquisa de doutorado, como ferramenta auxiliar no ensino do uso do Soroban para estudantes com deficiência intelectual. A validação desse material deu-se por meio da pesquisa qualitativa, sendo utilizada como estratégia a pesquisa-ação. O material foi utilizado por oito estudantes com deficiência intelectual que frequentavam o programa Educação de Jovens e Adultos de uma escola de educação especial. Os resultados revelaram que o uso do Soroban Dourado no processo de ensino promoveu a compreensão dos estudantes sobre a estrutura do Soroban, o entendimento*

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dos princípios do sistema de numeração decimal como o valor posicional, agrupamentos de dez em dez e a aprendizagem dos conceitos matemáticos relacionados aos números e operações. Esses resultados evidenciam a importância de um ensino que considere as capacidades dos estudantes com essa deficiência e não suas limitações, assim como o fato de que todas as pessoas, independentemente de qualquer condição, podem aprender e se desenvolver, desde que lhes sejam dadas as condições necessárias para isso no processo de ensino.

***PALAVRAS-CHAVE**: Ensino de matemática. Deficiência intelectual. Soroban. Aprendizagem.*

***RESUMEN**: El objetivo del presente trabajo, que se desarrolla como producción técnica de investigación de doctorado, es discutir la utilización del material Soroban Dorado como herramienta auxiliar en la en la enseñanza del uso del soroban a estudiantes con deficiencia intelectual. La validación de este material se dio por medio de investigación cualitativa, siendo utilizada como estrategia de investigación-acción. El material fue utilizado por ocho estudiantes con deficiencia intelectual que frecuentaban el programa Educación de Jóvenes e Adultos de una escuela de educación especial. Los resultados revelaron que el uso del Soroban Dorado en el proceso de enseñanza promovió la comprensión de los estudiantes sobre la estructura del soroban, el entendimiento de los principios del sistema de numeración decimal como el valor posicional, agrupaciones de diez en diez y el aprendizaje de los conceptos matemáticos relacionados con los números y las operaciones. Estos resultados evidencian la importancia de una enseñanza que considere las capacidades de los estudiantes con deficiencia y no sus limitaciones, así como el hecho de que todas las personas —independientemente de cualquier condición— pueden aprender y desarrollarse desde que se les proporcionen las condiciones necesarias para ello durante el proceso de enseñanza.*

***PALABRAS CLAVE**: Enseñanza de matemática. Deficiencia intelectual. Soroban. Aprendizaje.*

Introduction

This article is part of a doctoral research developed at a public university in the state of Paraná, which investigated the contributions of the use of Soroban in learning content related to numbers and operations and the development of the higher psychological functions of students with intellectual disabilities. The aim of this article is to discuss the use of the Golden Soroban didatic material in the teaching process for using Soroban – Japanese abacus – for students with intellectual disabilities.

The American Psychiatric Association (APA) defines intellectual disability (intellectual development) as a disorder "[...] beginning in the period of development that includes functional deficits, both intellectual and adaptive, in the conceptual, social and practical domains" (APA, 2014, p. 33).

Vigotski (1896-1934), in his studies on intellectual disability, questioned the classification evaluation of these people through quantitative tests. According to Vigotski (1997), these tests inform the real development of the person and do not indicate the processes in development, which cannot be measured quantitatively. He also stated that people with intellectual disabilities cannot be considered less developed, but developed differently, peculiarly.

Another position questioned by Vigotski (1997), concerned the education of people with intellectual disabilities, based on the excessive use of concrete materials in the teaching of school concepts. For him, concrete experiences are mediating instruments, however, their use as the only methodological resource limits the development of abstract thinking.

By thinking about the capacities of people with disabilities and not on their limitations, Vigotski (2000) found that learning drives the development of higher psychological functions, specific functions of the human being, related to mental abilities such as language, memory, attention, reasoning, among others. The theoretician also considers that learning, when creating zones of proximal development, characterized by the interval between what the child can do with the help of others and what they can do alone, stimulates internal development processes. In this course, interaction with other people and mediation, through instruments and signs, are of fundamental importance, since knowledge is socially produced and, when internalized, becomes part of acquisitions of individual development, resulting in mental development, boosting the person with intellectual disabilities for compensation.

It is also pointed out that it is necessary to maximize access to knowledge, overcoming the gaps in the teaching and learning process for these students. When considering these facts, the teaching of Soroban as a tool for performing mathematical calculations was proposed for this research.

It is understood that the use of this tool simplifies and streamlines the calculation, as Kojima (1954) stated many years ago, and consolidates the educational process, such as the learning of mathematical concepts related to numbers and operations, the development of mental calculus, memory, thought and others (DONLAN; WU, 2017; FREEMAN, 2014; BRAZIL, 2012).

In view of the proposal to teach the use of Soroban as an instrument for calculations aimed at students with intellectual disabilities, the question arose about how to teach them the structure, so that they understood the principles of the decimal numbering system and the combination of the system of basic groupings five and base ten present in its structure. According to Galperin (2009b), in the learning process it is necessary that students act on the

object of knowledge so that there is an understanding of the phenomena, first in the material and language plan and, finally, the internalization of these actions in the mental plan.

It was verified, through observations in teaching and learning process for students with intellectual disabilities, the difficulty in understanding the concept of number and the principles of the decimal numbering system. People with this disability present difficulties in skills that require the development of higher psychological functions such as attention, perception, memory, language and thinking (PASSOS-SANTOS; SHIMAZAKI, 2020).

Verifying such difficulties led to the development of a teaching material that minimized or eliminated the possible difficulties that would be presented by the students during the study. In this sense, the Golden Soroban didactic material *was elaborated,* with the objective of promoting the understanding of the structure of Soroban by students with intellectual disabilities in the teaching process of the use of this tool.

The Golden Soroban is considered a material of unprecedented nature and innovative potential, since, for its conception and subsequent filing for patent application, it was sought in three patent filing bases, National Intellectual Property Institute – INPI, Latipat and Espacenet, the existence of some material with the same characteristics and objectives in the teaching process of the use of Soroban. In the research state of the art there are no records of didactic materials developed in order to explain the structure of Soroban. Some records [4]found, although they have in common the objective of facilitating the teaching and learning process of Soroban, did not present technical characteristics for the transposition of the logical rules of the decimal numbering system to the Soroban and did not share similarities in its design, arrangement or composition.

Similarly, in state-of-the-art research, there are no studies on the teaching of the use of Soroban for populations with intellectual disabilities in the national scene. Studies were found that discuss teacher training for soroban teaching (SILVA; MAMCASZ-VIGINHESKI; SHIMAZAKI, 2018; OLIVEIRA, 2016; SILVA; MAMCASZ-VIGINHESKI; SHIMAZAKI, 2016; VIGINHESKI; SILVA; SHIMAZAKI, 2014) and the process of teaching and learning operations for students without disabilities (SOUZA FILHO, 2013).

On the international scene, research on Soroban in the field of education has as target audience teachers, students with learning difficulties and visual impairments (DONLAN; WU,

[4] RO201500017 – Abacus of reconfigurable panel type; CN205028192 - Five Elements'Abacus; CN204740770 - Vertical abacus teaching appearance; CN104867376 - Education mathematic abacus; CN204423721 - Multifunctional abacus for teaching; CN201562380 – Easy-reset abacus for teaching purpose; US2005130106 - Mathematical training abacus Systen; KR810002211 - Abacus for teaching; MU7402504 - The game educational towards initiation from Soroban and sorobani.

2017; FREEMAN, 2014). The research developed by Shen (2006), in China, discusses the contributions of mental abacus, a step after teaching the use of physical abacus, in the development of calculus skills by students with intellectual disabilities.

Thus, the field of investigation about the contributions of Soroban and the development of Golden Soroban, an assistive technology resource, for the teaching of mathematical concepts to students with intellectual disabilities, was verified, since there are a number of young and adult students who attend schools and often do not appropriate the concepts taught there. Thus, the discussions present in this study present advances, both for the area of special education, as for the area of inclusive teaching of Mathematics.

The design of the Golden Soroban

The Golden Soroban was conceived when considering the need for assistive technology for the appropriation of knowledge that is considered one of the instruments for the social participation of people, whether with disabilities or not. The resources of Assistive Technology, as Matos *et al* point out. (2020), are considered a strategy for accessibility and school inclusion of students with disabilities because they enable "[...] adequate conditions for safe and autonomic use, total or assisted school materials and pedagogical resources that respond to the demands of tasks to be performed inside and outside the classroom" (p. 942). In the search for an assistive technology that associated the structure of Soroban with those already used, especially the golden material, the didactic material called Golden Soroban was elaborated. This name was chosen because the material presents the soroban structure and because it uses golden material for the structuring of the decimal numbering system.

The prototype of the Golden Soroban consisted of a rectangular table, divided into three vertical parts by embossed lines, to represent the orders of the units, tens and hundreds, as well as divided into two parts, the top and the bottom, in the horizontal direction. In the first part, from right to left, four cavities are contemplated at the bottom to fit a cubic unit in each, and a cavity at the top for the fitting of a bar containing 5 grouped cubic units. In the second space, the four cavities at the bottom allowed the fitting of bars containing ten cubic units grouped, and at the top the fitting of a plate containing fifty cubic units grouped (5x10). In the third part, four plates containing one hundred cubic units were grouped in the lower cavity and the cavity of the upper part allowed the fitting of a cobblestone, containing five hundred cubic units grouped, five cubic units of width, ten cubic units of length and ten cubic units of height. In

each of the parts was inserted an axis similar to the soroban axis, containing 4 beads at the bottom and 1 beaded at the top of each axis.

The difference between this material and the value-place poster, the golden material separator, is the existence of pieces that represented the quinary base of Soroban, such as the bar with five cubic units grouped together, the plate with fifty cubic units and the parallelepiped with five hundred cubic units, in addition to the axes corresponding to Soroban.

Figure 1 represents the Golden Soroban:

Figure 1 – Golden Soroban

Source: Collection of the authors

The top surface is divided by a ruler, in the direction of length, into two pieces, the top and the bottom. In relation to the width, the surface is divided into three columns, and in each of these columns there are cavities for the fitting of the golden material and an axis under which the beads slide, similar to soroban. Figure 2 illustrates an example of registering the numbers in the Golden Soroban, in this case, the number 148.

Figure 2 – Representation of number 148 in Golden Soroban

Source: Collection of the authors

For a better understanding of the record of this number, Figure 2 shows that in the first column from right to left the bar at the top represents the five units, which, added with the three units at the bottom, total eight units. On the soroban axis corresponding to the units, immediately to the left of that first column, the top bead is approximated to the central ruler, as well as the three beads at the bottom. In the second column are arranged four bars representing the four tens and, likewise, on the axis to your left, the four beads at the bottom are approximate to the mark that parting the two pieces. In the third column one has a hundred embedded at the bottom, as well as an approximate soroban shaft bill of the central ruler.

Methodology

The research, of an applied nature and a qualitative approach, used action research as a strategy, since, in addition to being a technique for collecting and processing data, it also allows the teacher to become a researcher of their own practice. and a participant in the teaching action that intervenes in the directions of this action (FIORENTINI; LORENZATO, 2012).

The research was developed in a youth and adult education class with a special education school in the area of intellectual disability, in a municipality in the interior of the state of Paraná. Participants were 8 students, 07 males and 01 females, whose ages ranged from 19 to 47 years. In addition to academic activities, students participated in activities related to professional education in bakery.[5]

For the development of action research, the steps established by Engel (2000) and Thiolent (1996) were followed, among them: i) preliminary research, through observation of the classes taught by the teacher of the class; ii) the development of a problem: What contributions can the use of Soroban make to the learning of the thematic unit numbers in students with intellectual disabilities? iii) the establishment of a guideline for research: the use of Soroban, combined with an adequate teaching methodology, can create zones of proximal development in students with intellectual disabilities, who will have advances in their knowledge about aritmetics, with possibilities to expand the social use of this content and promote the development of higher psychological functions. This guideline was elaborated based on the studies developed by Vigotski (2001; 2000; 1997), Galperin (2009a; 2009b; 2009c) and Talizina (2009) on learning and development, and in studies on Soroban conducted by Donlan; Wu (2017), Freeman (2014), among others; iv) development of an action plan; v)

[5] The search Was submitted to the Ethics and Research Committee of the Federal Technological University of Paraná and approveda opinion 953.511.

implementation of the action plan and vi) analysis and evaluation of the implementation of the action plan.

The development of the action plan took place through pedagogical intervention, in which didactic sessions were held to teach the use of Soroban and content numbers and operations, organized according to the guidelines of Vigotski (2000), Galperin (2009c), Talizina (2001) and Fernandes *et al*. (2006). The implementation of the action plan lasted 40 hours, divided into two weekly sessions lasting 2 h each.

In teaching the use of Soroban, the historical aspects of this calculation tool were addressed and activities of recording and reading numbers, adding and subtracting numbers and problem solving were developed. The Golden Soroban was used whenever the students presented some difficulty in performing the proposed tasks. Table 1 presents a summary of the activities proposed for the teaching of soroban:

Table 1 – Summary of activities

THEMATIC UNIT	KNOWLEDGE OBJECTIVES	MATERIAL USED	CONTENT WITH THE USE OF SOROBAN
Numbers	Count. Number recognition in the daily context. Quantification of elements in a collection. Reading, writing and comparing numbers. Composition and decomposition of natural numbers. Complementary numbers. Problems involving different meanings of addition and subtraction.	Chip games. Numerical rulers. Clothesline with clothes fasteners. Golden material. *Golden Soroban.* Soroban.	Historic. Registration and reading of numbers. Addition. Subtraction.

Source: Elaboration of the authors

For the analysis and evaluation of the implementation of the action plan, the data, collected through films and field diary records, were examined through the analysis of the conversation, focusing on the context of the actions and their interpretations (FLICK, 2009). For this, the films obtained were fully transcribed, preventing details from going unnoticed. After the identification of episodes, elements were selected for the analysis, considering the theoretical assumptions adopted for the research.

Results and discussions

At the beginning of the research, it was found that the majority of the students in the class had not yet appropriated the concept of number. The fact that the students recognized some digits and had the knowledge that the symbols were related to numbers, quantified small

amounts and presented an initial understanding of the social function of this concept in their lives, did not mean that they had consolidated this concept (TALIZINA, 2009). The actions of counting and doing operations had not been defined, but they related these concepts to daily actions, that is, at the level of spontaneous concepts and not of scientific concepts (VIGOTSKI, 2001).

In the sense of some students, the number was a symbolic representation, dissociated from a quantitative value, which could be the result of a teaching through repetitive activities, which favored only the tracing of the digits without establishing a relationship between number and digit and the signified of this relationship. As a result, pre-Soroban activities were used because carrying out operations with Soroban requires the concept of number and decimal numbering system. Among the activities, we used the game *Never Ten Loose* with the golden material. In the rules of the game, the player, in his turn, throws a die and separates for himself the amount of cubic units corresponding to the number drawn. When accumulating ten cubic units, the player exchanges for a bar, which represents the ten, and ten bars are exchanged for the plate, which constitutes the hundred. Whoever gets the hundred first wins the game. A variation of the game is to start by the hundred. In the rounds the students return the amount of cubic units drawn in the data, winning the first one that is left with nothing (FERNANDES *et al.,* 2006). The game was carried out through the use of Golden Soroban to register the quantities and, later, with the use of Soroban.

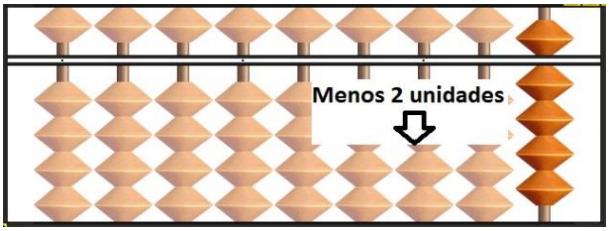
Initially, students were asked to perform small amounts and operations in Soroban, such as 1+1; 2+2; 3+1; 4-1; 4-2 and others. These operations did not require students to calculate mental, since it was only necessary to withdraw or add amounts to those already registered in soroban. These operations were performed by the students, since they understood the quantities up to four.

In the first contact with the tool, the students Maria, Tiago and Hélio approximated more beads on the numbering ruler than requested, possibly because they still did not properly count quantities with more than three or four objects. The students performed addition and subtraction operations: these activities also promoted reflections about these operations being inverse of each other. An example of this is the speech of Pedro, who, when performing the operation 4-1, pointed out: “if four minus three is one, four minus one can only be three”.

The students presented difficulties in registering number five with the use of Soroban. The use of Golden Soroban promoted this understanding, since it allowed the visualization of the five units represented by the bar embedded in the upper cavity of the first column (Figure 2).

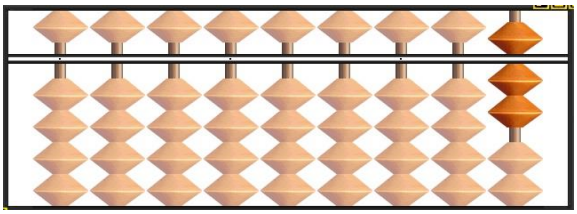
After recording quantities between five and nine units, students were asked to perform other operations, including 4+1; 5-2; 3+2; 5-4; 5+3; 9-2; and others. In these, the calculation was no longer mechanical, and it was necessary to perform the operation mentally to record the answers. An example of this was operation 9-2. To this end, the students registered the number nine, and with an automatic movement they removed two beads from the bottom, an action represented in Figures 3 and 4.

Figure 3 – Representation of number 9 in Soroban



Menos 2 unidades = minus two units
Source: Collection of the authors

Figure 4 – Result of operation 9-2=7



Source: Collection of the authors

It is noteable that the reading of the result recorded in Soroban, expressed in Figure 4, was carried out with difficulty and with the help of the researcher. At first, the students Fabricio, José and Pedro answered that the difference was three, because they considered the top account also with the value of a unit. It was necessary to resume in Golden Soroban the value of five units in the top account; they counted the cubic units placed in the upper cavity of the first part and associated this value with the top of the first axis, and read 5, 6, 7. It was consulted several times until internalized the value of the top account, no longer being necessary to use the didactic material for this situation.

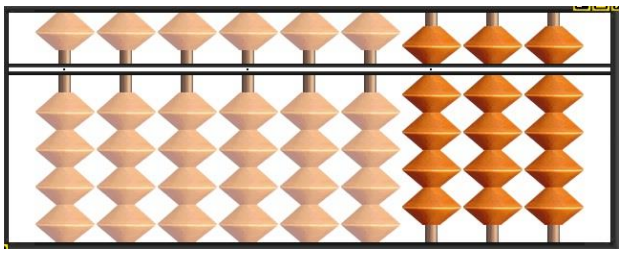
Another operation that brought difficulties to the resolution was 5-1. To solve this operation, one should resort to the complementary numbers of the number 5, in this case, 4 and 1, remove the number five from the top and record the number four at the bottom. José wanted to take beads of other axes, and when told that he was working with units, registered only in the first axis, he replied: “you don't say where it is to take it from”. The speech reveals the dependence of the teacher on the student in carrying out the activity, possibly caused by

teaching situations in which he was not encouraged to think and act independently, or fear of making mistakes and being criticized for doing so. To solve this operation, it was also necessary to use the Golden Soroban and contextualization with everyday problems, such as the use of money.

As the subjects formed the concept of number, such as, understanding larger quantities, using counting as a way of quantitatively evaluating a numerical set, understanding the change in number by adding or removing quantities, groupings of ten in ten, quantities greater than ten were worked, recording these quantities in the second axis of the soroban. They also had difficulties in understanding that the second axis was intended for the registration of groupings of ten units and the Golden Soroban contributed to this understanding.

For the registration of number twenty, Fabricio proceeded according to Figure 5:

Figure 5 – Registration of number 20 by Fabricio



Source: Collection of the authors

When asked if the number registered corresponded to number twenty, Fabricio replied: "*no, it was nineteen*". When asked why the registered represented 19, the student computed the element of the top of the first axis as five units and all others as one unit, including those of the second axis, totaling nineteen. The Golden Soroban allowed the understanding of the values assigned to the top beads, as well as the value assigned to the second axis beads. It was found that the difficulties of the students in the development of the activities arose because some of them had not appropriated the concept of number, the principles of the decimal numbering system, such as the base ten and the positional value, which made it difficult to record the numbers in the first or second axis of the Soroban; after this understanding, doubts were resolved with the use of Golden Soroban.

Galperin (2009c) points out that the number is the result of a mental action from a first action, which was material and, in the case of this research, the computation of objects. Even though some had not yet appropriated quantities greater than the tenth, the insertion of Soroban as an instrument for recording quantities and operations between them promoted progress in

the formation of the concept of number, since through it students operated with quantities, and not with its representation.

At the end of the research, it was found that three students, who at first comprised amounts of up to three, learned amounts greater than four and five units. Three students appropriated amounts greater than twenty, performing counts of two out of two, six out of six and groups of ten out of ten and the positional value, as well as making use of operations as a tool for problem solving, including addition and subtraction. One of them also learned multiplication by a digit. Two students did not show progress due to frequent absences on the days on which the research was conducted.

The Golden Soroban helped the students José, Pedro and Fabrício to learn registers and operations between numbers greater than five. When they did not know how to make the records, they resorted to Golden Soroban, and after using this material, they performed the same operations in soroban, understanding their actions. Teaching through the Golden Soroban allowed students, in the form materialized by Galperin (2009c), to understand the value of five in beads of the upper part, the composition of the numbers by means of complementary numbers, the positional value of the beads in the different axes defined by the decimal base, the need to regroup or exchange between quantities, among others.

The research proposed the introduction of Soroban as a calculation tool for teaching mathematics to students with intellectual disabilities in a country where its use is cultural only for people with visual impairment. Thus, in addition to the students learning the concept of number, they also had to learn the concepts related to the operationalization with Soroban and use it in the realization of the calculations.

As a result, it is also cited progress in computing skills, understanding of concepts, the application of skills developed in different contexts, in addition to schoolchildren, and the development of higher psychological functions.

Final considerations

Research shows that intellectual disability is not an obstacle to the learning of mathematical knowledge taught in school, however, for it to be effective, appropriate signs and mediating instruments are needed. The gaps generated in the learning process are often due to teaching methodologies that believe that all people learn in the same way and, as a result, do not meet the specific needs of students with intellectual disabilities.

It was found that the use of Soroban as a calculation tool promoted the learning of the content proposed for the study by students with intellectual disabilities. After carrying out the research, it is considered of great relevance the insertion of Soroban for the teaching of Mathematics for students with the highlighted disability, since it allows access to knowledge related to numbers and operations and facilitates its learning, besides enabling the development of new concepts, such as multiplication operations, division etc.

Likewise, it is noteworthy that the use of Golden Soroban promoted the understanding of the principles of the decimal numbering system and the structure and operation of Soroban, bringing contributions to the teaching and learning process for students with disabilities. Due to the fact that the material was used only by a population of students with intellectual disabilities, there is a need for validation by other populations, with other disabilities, in order to prove its efficiency and functionality as support material for teaching the use of Soroban.

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