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THE MAGIC CUBE AS A RESOURCE FOR DEVELOPING MATHEMATICAL SKILLS IN PRIMARY EDUCATION

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Abstract: This paper aims to present the Magic Cube game, identifying it as a resource that can be added to math classes in elementary school, in the final years. This aims to answer the following question: what mathematical skills and knowledge can be developed through the use of the Magic Cube in elementary school classrooms? In this way, the objectives were: to present the Magic Cube, identify skills and mathematical knowledge that can be developed in math classes that use it, which contributes to the teaching and learning process. To this end, the research was based on a literature review, related scientific papers and the BNCC for elementary school mathematics. From the readings and analysis, it was concluded that the Magic Cube is a resource that enables the development of various mathematical skills and knowledge.
Keywords: Magic Cube; Skills; Mathematical knowledge.

INTRODUCTION

Games and concrete materials are of great importance in educational research, as they are considered a means of understanding and intervening in children's cognitive processes, as well as representing for developmental psychology a dynamic activity that performs basic psychosocial, affective and intellectual functions in the development process.

With regard to concrete materials, it can be said that "they are of fundamental importance because, if used properly, students broaden their conception of what mathematics is, how and why they should learn it." (LORENZATO, 2006, p. 43). Regarding games, "one of the main reasons for introducing games into math classes is the possibility of reducing the blockages presented by students." (BORIN, 1996, p. 10). Both are playful and make abstract mathematics concrete. One example is the Magic Cube, a concrete material that can be adapted as a game if there is competition.

In this context, this paper aims to answer the following question: what mathematical skills and knowledge can be developed through the use of the Magic Cube in elementary school classrooms? It has the following objectives: to present the Magic Cube, to identify skills that can be developed in students during math classes that use it, contributing to the development of mathematical knowledge and helping in the teaching and learning process. To this end, the research was carried out by means of a literature review and related scientific works, associated with an analysis of the BNCC for elementary school mathematics.

THE GAME AS A TEACHING RESOURCE

Play has existed among animals and human beings since ancient times. However, play was introduced as a working methodology by great psychologists such as Lev Vygotsky and Jean Piaget.

In his work *The Social Formation of the Mind* (1994), Lev Vygotsky discusses the role of play in children's development. According to Vygotsky (1994), play is seen not only as a pleasurable activity, but as a situation that arises from the desire to satisfy the needs of pre-school children and adolescents. They create an imaginary situation permeated with rules of behavior, thus concluding that every game with rules contains imaginary situations

Psychologist Jean Piaget (1978) became interested in the cognitive proposals that games and their rules developed, based on his research into the development of children's moral judgment. Dell'agli (2002) says that Piaget characterized games as: exercise games, because they serve to exercise and form habits in the child; symbolic games, which have the function of abstraction through comparison between a given element (object), an imagined element and a fictitious representation; rule games, which have a function in social or inter-individual relationships of a collective nature (players depend on each other and follow rules)

According to Rosamilla (1979), games and toys develop a sense of competence that makes people confident, have a sense of efficiency and self-respect, reducing their anxiety. Therefore, games function as resources that build ethical values that arise from the freedom they bring to players, who through imagination and creativity interact with themselves, with the game and with others, within rules established between them

In this way, games come into play in education, making it possible to associate the imaginary with systematic school knowledge. This ensures a deeper and more interactive involvement of students with their own knowledge, challenging them in how to think and solve mathematical problems.

Next, we'll look at the Magic Cube as a resource for developing mathematical skills and knowledge in the classroom.

MAGIC CUBE: HISTORY, TYPES, HOW TO USE IT

In 1974, Hungarian professor Erno Rubik invented a cube-shaped puzzle called the magic cube. The idea came from creating a prototype cube made of wood to illustrate the concept of the third dimension to his architecture students. After being patented and disseminated in Hungary, the game aroused curiosity among some mathematicians who took it to international conferences, arousing interest in other people. And in 1980, it was industrially produced and distributed worldwide, with 100 million cubes sold in just two years.

The Magic Cube is a puzzle in the traditional shape of a cube with 6 colored faces in blue, green, yellow, red, white and orange. Each face is made up of 9 squares, forming a 3x3x3 cube. It is made up of three types of pieces: the centers, which have only one color;

the middle, which have two colors; and the corners, which have three colors. Its 27 pieces are distributed as follows: six centers, twelve middles and eight corners.

In addition to the traditional 3x3x3 Magic Cube, there are other variations that differ in shape, such as: 2x2x2 cube, Pyraminx, Megaminx, 3x3x4 cube, 4x4x4 cube, Skewb.

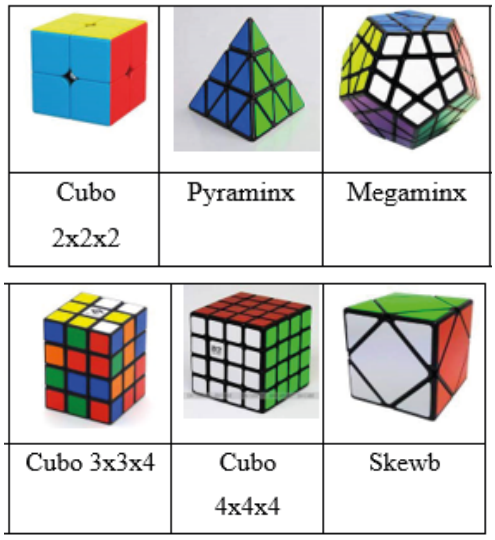

Figure 1 - Some types of magic cube.

Source: adapted from https://grauacao.alegre.ufes.br/conteudo/projeto-aprendendo-montar-cubo-magico (2022)

To solve the Magic Cube, you shuffle the pieces and then make moves so that the faces are once again made up of all the pieces of the same color. According to Silva (2015), there are a few methods of solving it, such as: the screwdriver method, which consists of rotating any face (45°) and sticking in a screwdriver causing a little cube to pop out of the cube and thus be able to take it apart and put it back together; the empirical method, in which random handling by trial and error can lead to being able to put it together; the strategic method (layer method), in which a set of algorithms is taken by carrying out tasks in a step-by-step tutorial system; the algebraic method, which consists of finding the solution by doing the math, using knowledge of Group Theory.

The idea of solving the scrambled Rubik's Cube is to do it without instructions, just by trying. However, "without instructions on how to proceed, it is almost impossible to solve, making the Rubik's Cube one of the most frustrating and addictive inventions ever produced." (SILVA, 2015, p. 16)

Therefore, the strategies involved in solving the Magic Cube awaken an understanding not only of the rules of how to complete the cube, but also develop mathematical skills and knowledge. These possibilities will be dealt with in the following topic.

THE MATHEMATICS OF THE MAGIC CUBE IN THE CLASSROOM

The first mathematical ideas to be explored with the Magic Cube are to use it to explore geometric concepts, such as volume, since it is a Plato solid whose faces are made up of congruent squares, where the colored faces arouse the students' curiosity to move and understand the elements that make it up. When used in Geometry classes, it will serve to "visualize and develop students' spatial reasoning, as well as learning the formulas and developing reasoning skills to calculate the volumes of some geometric solids." (MOURA, SILVA, SILVA E AMARAL, 2019, p. 7).

In this context, taking the BNCC (2018), it is possible to develop skill 24, from the 6th year of primary education, which says "solve and develop problems involving the quantities [...] capacity and volume (solids formed by rectangular blocks), without using formulas, inserted, whenever possible, in contexts arising from real situations and/or related to other areas of knowledge" (BRASIL, 2018, p. 303). 303), or skill 19, from the 9th grade, which deals with "solving and elaborating problems involving volume measurements of prisms and straight cylinders, including the use of calculation expressions, in everyday situations." (BRASIL, 2018, p. 319)

But also, according to the project with the Magic Cube applied by Tabuti, Azevedo and Nakamura (2016), the students did it:

> [...] calculations of the probability of the red face being positioned on the top face of the cube, as well as combinatorial analysis calculations to find out how many different ways you can get faces of one or two colors, identifying the position of the colors by manipulating matrices. In addition, the students developed logical reasoning skills and abilities in the application of the algorithms for solving the magic cube, which were motivated by the Magic Cube championship promoted by the students. (TABUTI, AZEVEDO E NAKAMURA, 2016, p. 132).

Thus, worked with in this way, the Magic Cube helps to develop skill 22 of the 8th grade, which refers to the study of probability, in which the student must "calculate the probability of events, based on the construction of the sample space, using the multiplicative principle, and recognize that the sum of the probabilities of all the elements of the sample space is equal to 1." (BRASIL, 2018, p. 315).

It is emphasized that other mathematical knowledge can be worked on and diverse skills will be acquired, as the Magic Cube helps in the development of "skills of analysis, synthesis and inference of logical reasoning and mathematical concepts that involve the elements of a Magic Cube such as vertices, edges and faces [...]." (TABUTI, AZEVEDO E NAKAMURA, 2016, p. 132).

In this sense, by working with the Cube in class, you can develop skill 17, from 6th grade, about "quantifying and establishing relationships between the number of vertices, faces and edges of prisms and pyramids, as a function of their base polygon, to solve problems and develop spatial perception". (BRASIL, 2018, p. 303).

It is also possible to work on notions functions, volume, symmetry, permutation and Algebra content, such as Abstract Algebra, contributing to the development of skill 21, from the 7th grade, which seeks to "recognize and construct figures obtained by translation, rotation and reflection symmetries, using drawing instruments or dynamic geometry software and link this study to flat representations of works of art, architectural elements, among others." (BRASIL, 2018, p. 309).

As for the skills developed by the students, "it is possible to perceive the Cube as an important teaching object, it captivates the student's attention and involves them in their activities, having the potential to work together with the teacher to perceive/discover the mathematical concepts that are present." (MACHADO, 2017, p. 5).

The extension project Unraveling the Magic Cube, implemented by the authors Juliana Moreno Oliveira, Gizele Geralda Parreira and Luciano Duarte da Silva (2019), aimed to teach the solution to the puzzle using the adapted sequential layer solving method (with seven steps, notations and algorithms) in order to develop logical thinking skills. The authors concluded that there was an "evolution in the potential of most of the participating students in terms of agility and speed to assemble the cube during the instructions of each meeting." (OLIVEIRA, PARREIRA E SILVA, 2019, p. 141).

Another proposal for an activity using the Magic Cube was applied in math classes taught in the 7th grade by Alecio Silva, Thalita da Silva, Weslley Barros and Valdson Silva (2016), in which they identified the application of Euclid's Division Algorithm and the steps involved in manipulating the Magic Cube. This was due to the fact that rotating the faces or combining the sequences of movements that, if performed repeatedly, return the faces to their initial position (completed faces). Thus, the authors themselves state that when handling the Cube:

> [...] repeated six consecutive times, the initial position is reached again. By relating each of the positions reached to the sequence of turns of the faces, they can be related to a possible remainder of the division of an integer by six. Showing that the cube is a model in which a system composed of the remainders of the Euclidean division of integers is evident, thus developing ideas such as sequential and periodic reasoning. (SILVA, 2016, p. 6)

It can be seen that this activity developed skill 34, referring to the 7th grade, which says that students should "plan and carry out random experiments or simulations that involve calculating probabilities or estimates by means of frequency of occurrences." (BRASIL, 2018, p. 311).

In short, the Magic Cube is a resource that can be used in various classes in the final years of elementary school, thus developing students' mathematical skills.

FINAL CONSIDERATIONS

This work looked at the mathematical skills and knowledge developed through the use of the Magic Cube in the teaching and learning process in elementary school, in the final years, based on a research carried out through a literature review and related scientific work, associated with the analysis of skills from the BNCC for Mathematics.

In order to gain an understanding of the pedagogical possibilities of this puzzle, the following objectives were set: to present the Magic Cube game, to identify the skills developed in elementary school students based on the BNCC for Mathematics and to recognize the mathematical knowledge involved that helps in the teaching and learning process.

As a result, the research has shown that the Magic Cube is a resource that enables the development of various skills, such as attention, agility, spatial and numerical reasoning, and mathematical knowledge, such as the concepts of calculating areas, volume, functions and abstract algebra. Thus, the game shows its pedagogical potential in the classroom, and in teaching mathematics, it brings a breadth of knowledge that ranges from basic content to complex topics.

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