

# USE OF THE RUBIK'S CUBE IN ELEMENTARY SCHOOL AS A MEDIATING RESOURCE FOR INTERDISCIPLINARY LEARNING OF MATHEMATICS AND PHYSICAL EDUCATION IN A HISTORICAL-CULTURAL PERSPECTIVE

Alexandre BARAI

Prefeitura Municipal de Araras Brazil

ORCID ID: <https://orcid.org/0000-0002-5503-5388>

[alexandrebarai@outlook.com](mailto:alexandrebarai@outlook.com)

João Teles de CARVALHO NETO

Federal University of São Carlos, Brazil

ORCID ID: <https://orcid.org/0000-0001-7917-2478>

[jteles@ufscar.br](mailto:jteles@ufscar.br)

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## Abstract

The Magic Cube is a three-dimensional puzzle created by teacher Erno Rubik as teaching material to work with his students on the concept of three-dimensionality. When building a cube on axes he realized he had created a puzzle. Current educational proposals encourage the use of games as a teaching resource in teaching skills and competencies. Mediated by an interdisciplinary proposal of Mathematics and Physical Education, this qualitative study sought to use the Cube as a complementary teaching material exploring its full potential for learning of mathematics and Physical Education. Based on the historical-cultural perspective, its main objective is to understand how the use of toys can contribute to the development of logical-mathematical and cognitive-motor skills in 5th grade Elementary School students. The study highlight that the use of toys encourages the appropriation of various skills contained in educational proposals for Mathematics and Physical Education. In this way, within the limitations of an exploratory-descriptive study, the study recommends that it is feasible to use the Rubik's cube as a complementary teaching resource that stimulates the development of higher psychological functions, helping both the appropriation of culture and systematized knowledge, and favors the formation of scientific concepts.

**Keywords:** Teaching and learning, interdisciplinarity, elementary school mathematics, physical education, mediation theory.

## INTRODUCTION

The Rubik's Cube, popularly known as the Magic Cube, is a three-dimensional puzzle created by Hungarian professor Erno Rubik as teaching material in 1974. His objective was to work with his students on the concept of three-dimensionality. However, by building a cube on axes that allowed all six faces to rotate, he soon realized that he had created a puzzle (Barbosa, 2019; Oliveira, et al., 2017; Rodrigues & Silva, 2013; Roncolli, 2016).

The importance of the didactic function of toys, games and the manifestation of play in the processes of intellectual development was described by Vygotski (1989). Reiterating that the stimulation of curiosity based on the intrinsic challenge of playful activity makes it possible to overcome obstacles in problem situations that arise before the player, promoting the possibility of developing language, thinking, concentration and attention, leadership, cooperation and of ethics.

The importance of games is also mentioned in reference documents on Brazilian education. The National Curricular Parameters (NCP) reiterate that the game generates student interest in the proposed challenge, promotes processes that stimulate reasoning, teaches how to deal with symbols and think by analogy, culminating in language production. In this sense, it is up to the teacher to analyze the educational potential of the game and curricular aspects such as: skills and abilities associated with its practice (Domenici & Recco, 2008).

In Brazil, the National Common Curricular Base of Physical Education has a specific thematic unit of games and play that covers the 3rd to 5th grades of Elementary School. On it, one of the Objects of Knowledge are the world's popular games. The teaching of the Rubik's cube fits within that unit and recognizes the possibility of experimenting and enjoying these games, valuing their importance as cultural heritage. Within mathematics, that theme can be inserted into intellectual games, favoring the development of reasoning, and can be used as a resource to support the understanding of various objects of knowledge specific to that subject (Brazil, 2018).

Although most people have already had contact with a Rubik's Cube at some point in their lives, it is common sense that that puzzle proves to be an almost impossible challenge to solve (Barbosa, 2018). In this way, this article aims to outline how a master's thesis research inserted the 3x3x3 cube as a mediating teaching material in a public school, researching its potential as a pedagogical resource in an interdisciplinary way, exploring its use in the curricular components of Mathematics and Physical Education supported by Historical-Cultural Theory.

In that process, we demystify the impossibility of its resolution, encouraging the implementation of an integration of the different knowledge promoted through the two curricular components, mediating the appropriation of skills and competencies. In the end, we seek to understand the relationship between 5th grade of Elementary School students with the Rubik's Cube, aiming to develop logical-mathematical, cognitive and motor skills, and how the interaction between teacher/student(s) contributed to the formation of those skills, addressed through interdisciplinary work in Mathematics and Physical Education.

## METHOD

### Study Design

The study began after carrying out searches in the databases of educational journals such as: ERIC (Institute of Education Sciences), Google Scholar, Educ@ (Online education publications - SciELO methodology), BDTD (Brazilian Digital Library of Theses and Dissertations). The researchers observed limited studies on the use of three-dimensional puzzles as a didactic activity in Mathematics classes in Elementary School, there is also a lack of studies that relate the Rubik's cube as a game in Physical Education, added to the limitations of studies that touch on interdisciplinarity between the two curricular components.

Thus, this study was exploratory, as it sought to observe and understand the use of three-dimensional puzzles based on the lives and experiences of the subjects participating in the research, expanding our knowledge about human behavior in the social context where it occurred (Gil, 2017; Piovengan & Temporini, 1995). Now it had a descriptive character that used a qualitative approach describing the characteristics of the group of people studied, through the analysis of the collected data, establishing relationships between the variables with the phenomenon and the process, thus verifying its developments (Gil, 2017; Raupp & Beuren, 2006).

Those results were examined and subjected to critical reflection based on the Historical-Cultural Perspective (Langemeyer, 2015).

Since each science has their specific object of study, therefore, to study any one of them, a specific method is necessary. The method is a path, a procedure. As it is a procedure, consequently, it depends on the objective towards which science is oriented in a given field. If each science has its specific attributions and objectives, then, of course, it also develops its specific study methods, its paths of investigation. Thus, it can be said that, in the same way that there is no science without its object, there is also no science without its method (Vygotsky, 2018, p.37).

In this sense, we understand that the cultural historical perspective was fully aligned with the object of study of this academic research. Data collection occurred through the following research instruments: (i) semi-structured interview to students and teachers participating in the research; (ii) observations of

the dynamics of the assembly workshops noted in a field diary; (iii) dialogue with teachers who worked on implementing academic activities; (iv) teaching how to assemble the toy.

### **Location, participants, and procedure**

The research was conducted at a full-time municipal public school situated in Araras, a city in the countryside of the State of São Paulo. In early March, a meeting took place during collective pedagogical work hours (HTPC) with the teachers invited to participate in the study, aiming to align the initial prototype strategies. During this meeting, several decisions were made: the assembly workshops would commence in the second week of March, a brainstorming session to generate possible interdisciplinary didactic actions for the prototype was conducted, and three additional sessions for discussions and alignments were scheduled for the following months. Ultimately, the duration of the prototype was set to extend until the conclusion of the first academic semester.

Verification of the logical-mathematical and cognitive-motor skills of the academic activities planned for both disciplines was essential. It was also necessary to discuss the preparation of specific activities. Notably, the activities related to the toy were integrated as regular pedagogical activities, facilitating the incorporation of planned contents throughout the study period.

The study involved three teachers—one from physical education and two from education—alongside 53 students interested in learning how to assemble a Rubik's Cube. Among these students, 27 belonged to class 5A and 26 to class 5B. Initially, 18 toys were purchased for the workshops, with additional copies acquired as the prototype progressed. The assembly workshops were conducted twice a week, on Mondays and Thursdays, following lunch breaks, averaging a duration of 30 to 45 minutes. A total of 31 workshops occurred during lunch hours, complemented by 4 regular Physical Education classes, summing up to 35 workshops from March 15th until the end of June.

Students received guidance either in groups or individually based on the step, necessity, or difficulty of the task. They were encouraged to seek clarification from other students in the school who had mastered the assembly process, primarily during breaks or with teachers' authorization. Initially, for home study, utilizing tutorials available on the internet was suggested as additional learning support.

It's important to highlight that in historical-cultural research grounded in Psychology, one of the fundamental principles is intervention. To investigate "higher mental functions," it's imperative to create them. In that context, the individuals involved in the study are not perceived as a sample but rather as a prototype. Distinguishing from a "sample," the term "prototype" implies novelty and allows for adjustments, mediations, and reflections during the study, as it's not a pre-established and immutable sample but an adaptable "prototype" influenced and modulated by historical-cultural aspects. Therefore, following Vygotsky's perspective, the method becomes both a prerequisite and a product, a tool, and a result of the study. Hence, in this study, the term "prototype" is used to refer to the research group (Langemeyer, 2015).

The construction of a prototype necessitates involvement from all participants. Hence, this methodology remained flexible, adapting to the needs of its participants, enabling the integration of theoretical work with empirical-practical aspects. Consequently, the method of this study was concurrently a prerequisite and a product of the actions experienced by its participants, possessing an intersubjective character, and deviating from the typical objectification inherent in research methodologies (Langemeyer, 2015).

### **Ethics**

Students enrolled in the 5th grade from two classrooms, expressing interest in learning how to assemble the toy and authorized by their guardians, were included in the study. The students' ages ranged between 9 and 11 years old, with no exclusion criteria established.

This study obtained approval from the Ethics and Research Committee of the Federal The University of São Carlos, under opinion number 5.524.268. All guardians of the participants were informed about the study's objectives, and those who agreed to their child's participation signed the Free and Informed Consent Form (TCLE). Additionally, the participating students signed the Minor Assent

Form (TAM), while Image Rights (ID) were obtained for six students. However, students uninterested in participating or choosing to withdraw from the research were informed that they could leave the workshop at any time without any negative repercussions. In either situation, they would automatically be excluded from the group constituting the prototype for this study.

### **Data Analysis**

A qualitative analysis approach was used based on observations made during the 16 weeks within that prototype. This includes Rubik's Cube assembly workshops, classroom activities, semi-structured interviews with students and teachers, informal conversations among teachers, and engagement with various members of the school community. Through those methods, we aim to address the central research question: How can the application of the Historical-Cultural Theory shed light on and help comprehend the didactic strategies for teaching logical-mathematical and cognitive-motor skills, utilizing the Rubik's Cube in 5th-grade classrooms of Elementary School? Additionally, we aim to capture insights from the three teachers involved in the study, each possessing over 18 years of teaching experience.

## **RESULTS AND DISCUSSION**

It's essential to emphasize that the prototype, as a master's thesis research project, is a historical-cultural product. Consequently, it followed its rituals, including its intentions, deadlines, and academic objectives. As outlined in the methodology, it spanned 16 weeks, concluding simultaneously with the end of the first academic semester. However, the workshops and informal discussions among the involved teachers, aimed at continuing school initiatives, recommenced at the beginning of the second semester in August and persisted as a didactic approach until October's conclusion. To culminate the year's efforts, we organized a 3x3x3 cube assembly championship for the students.

An important observation made from the study was the significant impact of using toys as educational resources, acting as cultural mediators within the school environment. Consequently, students, being historical-cultural entities, interacted in various ways within everyday school life. Those interactions occurred among siblings attending different school years, within diverse friendships, and even among students arriving at school via school transportation. Those connections led to students from various classes bringing three-dimensional puzzles to school, establishing the toy as a cultural mediator within the school community. This phenomenon prompts us to consider the possibilities of leveraging this resource across all Elementary School grades.

Some 3rd and 4th grade students learned to assemble the toy through peer assistance or by following tutorials on platforms like YouTube. That underscores the toy's role as a cultural mediator, leveraging its inherent symbolism and stimulating higher psychological functions required for its manipulation. This revelation highlights its potential as a didactic resource within Elementary School. Furthermore, that dynamic aligns with Competency 8 of the National Curricular Common Base (BNCC) for Physical Education, advocating for autonomous engagement in bodily activities for enjoyment and enhanced sociability networks in leisure contexts.

An unforeseen development in that prototype was its extension to other models of three-dimensional puzzles, detailed in Table 1 below. Some students, both directly and indirectly involved in the study, acquired proficiency in assembling those puzzles. That aspect prompts reflection on how humans appropriate historical-cultural products available to them.

Moreover, by considering the toy's symbolic potential and its viable use in educational practices, intentional teaching can encourage both cultural assimilation and the dissemination of structured knowledge that facilitates the student's conceptual development. Those aspects correspond to Competency 2 of the BNCC for Physical Education, aiming to equip students to strategize and resolve challenges while broadening their cultural horizons.

**Table 1.** Videos of assembling three-dimensional puzzles made by students during the execution of the prototype

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**Cube 2x2x2**

<https://drive.google.com/file/d/1e-iBPUhKIARBRyM3AbG4f5K58StFqd55/view?usp=sharing>

**Cube 3x3x3**

<https://drive.google.com/file/d/1dpe-xoXcqsYaGXoQ5LP00C9XOtx32oR0/view?usp=sharing>

**Recreating possibilities in the cube 3x3x3**

<https://drive.google.com/file/d/1dxK2c2CxIndec2kevCPutdmh-f7ZaZhC/view?usp=sharing>

**Skewb cube**

<https://drive.google.com/file/d/1dn5719EvCuVDBYPSjPJYNWcngvstxU42/view?usp=sharing>

**Pyramid 3x3x3 (Pyraminx)**

[https://drive.google.com/file/d/1dl3sF1OJM3iEXVTtZmcJ\\_w6YHwxA0Y0/view?usp=sharing](https://drive.google.com/file/d/1dl3sF1OJM3iEXVTtZmcJ_w6YHwxA0Y0/view?usp=sharing)

**Last layer of the dodecahedron 3x3x3 (Megaminx)**

<https://drive.google.com/file/d/1djV1OWQ5SifWcz3CpEIgKe8aerGJZuFy/view?usp=sharing>

**Last layer of Mirror Blocks 3x3x3**

[https://drive.google.com/file/d/1s51zD5wQa0z7qE\\_ww0nobSOksgu7OZpI/view?usp=sharing](https://drive.google.com/file/d/1s51zD5wQa0z7qE_ww0nobSOksgu7OZpI/view?usp=sharing)

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Note. Prepared by the author (2022).

We believe that the learning of the 3x3x3 cube in the members of the prototype acted in the zone of eminent development. That statement is based on the need for individualized mediation support by the majority of students learning how to assemble the toy. We also infer that after appropriating the learning of that model, through the generalizations resulting from the various shuffles, there is an advance in the student's development zone.

That statement is referenced in those students who learned how to assemble other three-dimensional puzzle models. Because, unlike the 3x3x3 model, the learning of other models occurred mainly through tutorials available on YouTube, reducing teaching mediation to few doubts. That factor leads us to assume that those students made a leap from the possible development zone to the current development zone, in terms of the autonomy of learning how to assemble different three-dimensional puzzles. Since, there has been a maturity in the ability to learn assemblies practically without individualized instructional mediation (PRESTES, 2010; VIGOTSKI, 1989; 1991).

Even though the Rubik's Cube was used as a teaching mediating sign, through the aforementioned teaching intentionality, it is worth noting that the meanings attributed by the students varied, as could be observed in the semi-structured interviews. That factor is related to the different historical-cultural knowledge that each student carries throughout their life path. After having presented some more global perceptions of the prototype and elements not initially foreseen, but which were highlighted in the methodology that could be modulated in the face of research based on a cultural historical perspective, we will describe some points of the daily life of assembly workshops and their modulation during of the 16 weeks of the study highlighting three main moments.

### **The three moments**

As outlined in the methodology, the workshops systematically took place during the students' post-lunch hours, including part of their rest time. In other words, we started at around 12:05 pm and finished around 12:50 pm every Monday and Thursday. During that period, students were normally expected to have lunch from 11:55 am to 12:30 pm, after which there was a time for rest and hygiene that occurs from approximately 12:30 pm to 1:00 pm. Every Monday and Thursday, gradually, as they finished their meals, the students gathered in the school courtyard for assembly instructions.

In the first two weeks, the first moment we want to highlight, we made 10 units of the toy available, in which students worked in productive pairs, sharing the toy. However, fueled by the curiosity to learn

how to assemble, the number of interested students was greater than the availability of cubes, therefore, scheduling was necessary to carry out the workshops, as one person would not be enough to teach everyone interested at the same time. However, we understand that scheduling before learning is completed would hinder the development of the reasoning necessary to learn how to assemble the toy and would be unfeasible.

Aware of the challenge of serving a large group of students, from the 3rd week onwards we increased to 18 toy units, which were also added to other toys purchased by students, adapting the demand for necessary toys. But, with the increase in the number of students teaching simultaneously, the second moment that we want to highlight arises, that is, in this still early period of the workshops, in which only the research professor teaching in Physical Education knew how to completely assemble the toy, the need to adjust the prototype occurred again, as it was not possible to serve all students.

Even though we seek to group students for instructions according to the assembly step they were in, it is worth highlighting that, at the beginning of learning, the toy is somewhat complex. It takes some time to get used to and decipher a three-dimensional shuffle. To deal with that, it is necessary to make a series of inferences based on referencing and memorization. As a result, explanations also require significant time and, in most cases, individual intervention. And the sum of those factors meant that the researcher was unable to meet all the students in the time allocated to carry out the workshops.

As a result, at that moment, there was a certain lack of interest on the part of the students due to the difficulty in overcoming the initial stages of assembling the puzzle. Then, some students began to try to use their own strategies or even trick the assembly of the toy, rotating the corner pieces individually, or even removing and replacing the other pieces of the toy. It is worth noting that those maneuvers, in most cases, make it impossible to assemble the last layer of the toy, leaving it unresolved through assembly algorithms.

From that, we highlight the 3rd moment of the workshops, which was to restrict the number of participating students to ten students in the 5th week, until they completed learning how to assemble and could act as learning mediators, assisting the research teacher in the workshops. During that period, the students who were most advanced in assembling the puzzle were selected and, consequently, completed learning the puzzle more quickly.

We can see at that point in the prototype that the learning mediating action does not necessarily need to be carried out only by the teacher, because, after some of the students completed learning how to assemble the toy, they also helped the other students by mediating the teaching step by step of assembling the cube. From the moment the students passed from the zone of possible development to the zone of current development, appropriating the entire assembly system, they were also able to mediate teaching actions to their peers, who were still in the zone of possible development of the concepts of assembling the toy.

Then, from the 7th week onwards, the project returns to serve a greater number of students, encouraging interactions, productive groups, and partnership work. And from that moment on, that dynamic continued until the end of the 16th week. Figure 1 lists some photographs of the interactions mentioned above during the Rubik's Cube assembly learning workshops held at the school.

An important point to mention is that although this study intended an interdisciplinary teaching action in Mathematics and Physical Education, most of the workshops did not take place during regular Physical Education class times. Based on the pilot study by Barai (2020), I had already realized the difficult challenge of collectively teaching the assembly of the 3x3x3 cube to students in the 5th grade of Elementary School.

Perhaps an alternative to action within Physical Education classes would be to use the cube simultaneously with other reasoning games that students already master, for example: checkers, Nine Men's Morris, chess. And, based on that dynamic, begin teaching how to assemble the cube to a smaller group of students, until they can be teaching mediators, helping the teacher. In this study, we used four regular Physical Education classes as part of the teaching actions of that prototype. At a time when there were already students able to mediate, together with the teacher, the assembly of the

toy for the other students. Therefore, those classes served as a complement to the workshops held during lunch break.



**Figure 1.** Images from the author's collection of Rubik's Cube assembly workshops.

During the execution of the prototype, it was realized that in order for the use of the 3x3x3 Magic Cube in the 5th grade to be feasible, the teaching mediation actions for the majority of students need to add some subdivisions of the stages of teaching layered assembly recommended by Cinoto (2013) and Cerpe (2014). In general, the tutorials available on the Internet leave several implicit details for the learner to understand during the process of manipulating the toy. In this sense, when we noticed the difficulties that arose in the dynamics of the workshops, we tried to make a tutorial available on the YouTube platform through Professor Barai's channel, some subdivisions and clarifications that facilitate understanding and appropriation of assembling the puzzle.

Students who completed learning the 3x3x3 Rubik's Cube were encouraged to improve their assembly time through new algorithms taught by the teacher and by carrying out some formulas in an ambidextrous way. They were also encouraged to look for new puzzles to learn how to put together. In that dynamic, several students returned to school presenting new algorithms learned from Internet tutorials with the aim of optimizing the assembly time of the 3x3x3 cube. Others learned to assemble various toys, as already seen in table 1. We were able to frequently observe, in the assembly workshops, elements that lead us to assume the promotion of Competency 8 of the BNCC in Mathematics, as there were cooperative interactions between students, working collectively, helping

colleagues in the search for solutions to the puzzle. In this way, learning the steps of assembling the toy collaboratively (BRASIL, 2018).

Although the literature presents a large number of evidence that corroborates the use of the most diverse reasoning games as a didactic resource in teaching (Borges, 2018; Gasparello, 2018; Moreira, 2018; Parra, 2018; Senem, 2017; Gomes, 2017; Andrade, 2017; Roncolli, 2016; Grimm, 2016; Silva, 2015; Silva Júnior, 2012; Mattos, 2009; Grando, 2000). Regarding the use of the Rubik's Cube in Elementary School, given our searches, there seems to be no literature, neither for the teaching of Mathematics, nor for the use of games and games in Physical Education. We also remember that we did not find the use of other three-dimensional puzzles in literature as teaching resources. And that interdisciplinarity actions in Mathematics and Physical Education are still limited (Bravalheri, 2021).

It is important to highlight that, the way the Brazilian educational system is institutionally positioned, it is a challenge to achieve interdisciplinarity due to the few moments that exist to carry out study, planning, alignment of didactic actions and joint preparation of the academic activities that will be developed (FAZENDA, 2011). This study aimed to hold at least 4 alignment meetings to discuss possibilities for interdisciplinary actions mediated by the Rubik's Cube as a teaching resource. However, in practice we managed to carry out only two: the initial alignment as recommended in the methodology and a second meeting that also took place on HTPC day, when we discussed the possibility of exploring the elements that relate the toy with Geometry.

Although the teachers who made up that prototype have extensive school experience, in the year the prototype was created, the municipality underwent a textbook change, which resulted in new teaching dynamics that are still in the adaptation and transition phase. Such changes directed the teachers' training moments with the aim of appropriating the new material to be used, thus making the other two planned meetings unfeasible.

It is worth noting that many educational reforms and pedagogical projects are still dominated by aspects: ideological, political, financial and determinedly influenced by the forces that have social control, causing a mismatch between the proposals and their real applications, as they are normally based on studies that they appreciate the school from the outside in. Those factors, added to the disregard of current practices and traditions of school culture, usually cause many actions to be lost in bureaucratic ritualism that culminates in their discontinuity and/or failure (Viñao Frago, 2006; Julia, 2001).

During the foundation and carrying out of this study, we can see that even though recent Brazilian curricular proposals such as the Common National Curriculum Base and the São Paulo Curriculum have common objectives in the development of some skills considered general, the thematic units and objects of knowledge recommended are not necessarily aligned in order to facilitate interdisciplinary work. That is another complicating factor when the intention is to work on a set of different curricular components. Fazenda (2011) in his book had already highlighted that problem in older Brazilian education reference documents.

Even in the face of those challenges, through the conversation held with the teachers in the first meeting, we were able to list several contents and concepts that could be developed seeking to use the Magic Cube as a didactic resource in teaching, such as: shapes of geometric solids, face, vertex, edge, area, perimeter, clockwise and counterclockwise, aspects related to direction and location, notions of opposite sides, perception of three-dimensionality, rotation and translation, fractions and flattening of solids.

Among those, after the second alignment meeting between teachers, the Geometry Thematic Unit, its objects of knowledge, concepts and elements that were on the planned teaching route were explored in an interdisciplinary manner following the educational guidelines of the municipality during the period of completion of the prototype. To do that, they used their familiarity with the toy that circulated daily in the hands of students, exemplifying the contents and concepts.

According to the teachers' reports and according to their perceptions, the students' appropriation of the concepts of face, vertex, edge, and flatness of solids seems to have been facilitated with the use of the

toy. The students' daily contact with the Rubik's Cube also enabled a better understanding of the concept of solid planning. Those statements are empirically based on the previous experience of both teachers, who had more than 5 years of teaching experience in the 5th of Elementary School. Such factors corroborate competencies 2 and 3 of the BNCC Mathematics, as mediation permeated by the toy, helped in the development of logical reasoning, expanding the understanding of mathematical concepts and procedures, and expanding their ability to act in the world.

The failure to hold the last two meetings made it impossible for the teachers included in the prototype to prepare other intervention activities together, but it did not prevent interdisciplinary actions, as the teachers sought to explore in the Geometry unit of the textbook the possibilities of correlating the toy with the contents and concepts intermediated by their teaching practice. The following were worked on in general in the unit: geometric figures (polygons, quadrilaterals, triangles, solids); concepts of angles, vertices, edges, and flattening of solids. We assume that the process of interdisciplinary pedagogical intervention enhanced the appropriation and systematization of the concepts already mentioned, because, mediated by the concrete object, it was possible to observe regularities, verify hypotheses, and apply such ideas in other situations. Although we were unable to hold two of the planned meetings, it is worth highlighting that the daily working contact between teachers mediated general adjustments in the progress of the prototype and allowed for alignments regarding interdisciplinary educational practices in Geometry.

I remember that this study was carried out after the two most difficult years of the Covid-19 pandemic when face-to-face classes were back regularly. Chaotically, the pandemic promoted the rupture of school boundaries established two centuries ago. However, after its worst moment, we can also break with some attractive and innovative discourses that have been disseminated recently, such as: if learning happened “naturally”; that the physical school could be replaced by new technologies, and that artificial intelligence could replace the teacher. In contrast to these “illusions”, we highlight that education implies intentionality. In this sense, it is necessary to value the teacher, and access to a study space, and for this to facilitate the meeting (Nóvoa & Alvim, 2021).

Because the ills of public schools are commonly criticized in all areas of society. However, the period of closed schools during the pandemic demonstrated how public schools are a fundamental and essential institution in contemporary Brazilian society. If due to some neoliberal biases it performs the function of daycare and classification as mentioned by Perez Gomes (2001); Without it, society does not change, as stated by Paulo Freire (2000). Therefore, I understand that many criticisms directed at public schools would be dissolved if society as a community participated, experienced, and consequently, realized the importance of the school's role in transforming a society as unequal as Brazil's.

## **Conclusion**

Here, we delineate the final steps of this interventionist Historical-Cultural prototype, which aimed to comprehend interdisciplinary actions between mathematics and physical education mediated by the use of the Magic Cube in the 5th grade of Elementary School (Langemeyer, 2015). Our goal is to elucidate the importance of rigor in scientific practice, ensuring it remains integrated with teaching practices.

We recognize that processes of appropriation, both of culture and scientific knowledge, span time, culminating in historical, social, and cultural products (Vygotsky, 1989; Pinch & Bijker, 1984). Leveraging the potential of such products, fostered by the collaboration between academic research and schools, can significantly contribute to educational development. Moreover, fostering new research through collaborations between universities and schools could yield further insights. Indeed, the array of three-dimensional puzzles available for exploration as teaching resources holds promise for encouraging student development.

Our intention isn't to generalize the evidence unearthed in this prototype, as they mirror the understandings and perceptions of the subjects who experienced it. We emphasize that the intrinsic

peculiarities of the school culture among participants in this study must be considered (Viñao Frago, 2006).

Despite this, the presented results prompt us to infer those various qualitative elements, within the constraints of an exploratory descriptive study, indicated the feasibility of employing the Rubik's Cube in an interdisciplinary manner: combining mathematics and physical education in the fifth year of Elementary School.

Hence, it's plausible to foster the acquisition of diverse skills, including logical-mathematical and cognitive-motor abilities, ultimately fostering the development of higher psychological functions such as imagination, voluntary memory, perception, abstract thinking, attention, deductive reasoning, and planning capacity. In this regard, we believe that real-life situations, mediated through the dialectical relationship between teacher and student, form the foundation for broadening comprehension of societal symbols. They support knowledge systematization and, consequently, the historical-cultural assimilation of social and scientific concepts, thereby expanding individuals' capacity to engage in society.

Finally, as a researcher and educator in Basic Education, I aspire for this work to not only contribute to the academic community but also to reach the classroom. Bridging the gap between academic research and teachers in school settings, by furnishing educators with examples of successful practices based on scientific evidence, is pivotal for enhancing teaching-learning dynamics, culminating in transformative education.

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No funding was received from any individual or institution for this research.

### **Ethics and Conflict of Interest**

Students enrolled in the 5th grade from two classrooms, expressing interest in learning how to assemble the toy and authorized by their guardians, were included in the study. The students' ages ranged between 9 and 11 years old, with no exclusion criteria established. This study obtained approval from the Ethics and Research Committee of the Federal The University of São Carlos, under opinion number 5.524.268. All guardians of the participants were informed about the study's objectives, and those who agreed to their child's participation signed the Free and Informed Consent Form (TCLE). Additionally, the participating students signed the Minor Assent Form (TAM), while Image Rights (ID) were obtained for six students. However, students uninterested in participating or choosing to withdraw from the research were informed that they could leave the workshop at any time without any negative repercussions. In either situation, they would automatically be excluded from the group constituting the prototype for this study. The authors declare that they have adhered to ethical standards at all stages and declare no conflict of interest.

### **Author Contributions**

All authors made equal contributions to the conception, design, data collection, analysis, and writing of this article. All authors have read and approved the final version of the article.

### **Data Availability**

The data that support the findings of this study are available on request from the corresponding author.

### **Corresponding Author**

Correspondence to Philip Kipkosgei SAINA, [sainamailbox@gmail.com](mailto:sainamailbox@gmail.com)

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