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THE USE OF ORIGAMI IN THE DEVELOPMENT OF LOGICAL THINKING, MOTOR COORDINATION, AND SOCIOEMOTIONAL GROWTH

O USO DO ORIGAMI NA CONSTRUÇÃO DO PENSAMENTO LÓGICO, COORDENAÇÃO MOTORA E DESENVOLVIMENTO SOCIOEMOCIONAL

I EL USO DEL ORIGAMI EN LA CONSTRUCCIÓN DEL PENSAMIENTO LÓGICO, LA COORDINACIÓN MOTORA Y EL DESARROLLO SOCIOEMOCIONAL

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RESUMO: Embora seja uma prática antiga, a utilização do origami no meio educativo é relativamente recente. Estudos têm demonstrado que as dobras no origami podem transmitir claramente alguns conteúdos matemáticos, auxiliando no desenvolvimento lógico, criativo, imaginário e espacial. O processo de dobrar o papel exige coordenação motora fina, promovendo o aprimoramento da destreza manual e da precisão nos movimentos, e quando realizado em grupo, favorece a socialização, promovendo a troca de ideias e o trabalho em equipe. A atividade foi realizada em duas escolas do ensino fundamental I, em Laranjeiras do Sul (PR), no segundo semestre de 2024. A proposta envolveu a aplicação de dobraduras simples, como animais e personagens de desenhos animados, permitindo a manipulação de formas bidimensionais e sua transformação em tridimensionais. A escolha de modelos acessíveis garantiu engajamento, evitando dispersão e desinteresse, capacitando os estudantes a seguir sequências lógicas e organizar o raciocínio espacial. O origami permitiu a potencialização da criatividade, o desenvolvimento cognitivo e emocional, tornando o aprendizado dinâmico e interativo, mesmo dentro de uma perspectiva lúdica. Esse objeto de aprendizagem pode ser uma alternativa interessante para conectar a matemática ao cotidiano de forma envolvente e significativa.

Palavras-chave: Objetos de aprendizagem. Motricidade. Desenvolvimento cognitivo e emocional.

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ABSTRACT: Although it is an ancient practice, the use of origami in education is relatively recent. Studies have shown that folds in origami can clearly convey some mathematical content, helping with logical, creative, imaginative, and spatial development. The process of folding paper requires fine motor coordination, promoting the improvement of manual dexterity and precision in movements, and when done in groups, it fosters socialization, promoting the exchange of ideas and teamwork. The activity was carried out in two elementary schools in Laranjeiras do Sul (PR), in the second semester of 2024. The proposal involved the application of simple folds, such as animals and cartoon characters, allowing the manipulation of two-dimensional shapes and their transformation into three-dimensional ones. The choice of accessible models ensured engagement, preventing distraction and disinterest, enabling students to follow logical sequences and organize spatial reasoning. Origami allowed for the enhancement of creativity, cognitive and emotional development, making learning dynamic and interactive, even within a playful perspective. This learning object can be an interesting alternative to connect mathematics to everyday life in an engaging and meaningful way.

Keywords: Learning objects. Motor skills. Cognitive and emotional development.

RESUMEN: Aunque es una práctica antigua, el uso del origami en la educación es relativamente reciente. Los estudios han demostrado que los pliegues en el origami pueden transmitir claramente algunos contenidos matemáticos, ayudando en el desarrollo lógico, creativo, imaginativo y espacial. El proceso de doblar papel requiere coordinación motora fina, promoviendo la mejora de la destreza manual y la precisión en los movimientos, y cuando se realiza en grupo, fomenta la socialización, promoviendo el intercambio de ideas y el trabajo en equipo. La actividad se llevó a cabo en dos escuelas primarias en Laranjeiras do Sul (PR), en el segundo semestre de 2024. La propuesta involucró la aplicación de pliegues simples, como animales y personajes de dibujos animados, permitiendo la manipulación de formas bidimensionales y su transformación en tridimensionales. La elección de modelos accesibles aseguró el compromiso, evitando la distracción y el desinterés, permitiendo a los estudiantes seguir secuencias lógicas y organizar el razonamiento espacial. El origami permitió la potenciación de la creatividad, el desarrollo cognitivo y emocional, haciendo el aprendizaje dinámico e interactivo, incluso dentro de una perspectiva lúdica. Este objeto de aprendizaje puede ser una alternativa interesante para conectar las matemáticas con la vida cotidiana de una manera atractiva y significativa.

Palabras clave: Objetos de aprendizaje. Motricidad. Desarrollo cognitivo y emocional.

INTRODUCTION

The word "origami" has Japanese origins, derived from ori, meaning "to fold," and kami, meaning "paper." Just like the name, the practice of origami is traditionally associated with Japan (TURNER N, et al., 2016; LANG RJ, 2007). This art form was exclusive to the Japanese elite, as paper was considered a luxury item and not easily accessible to other social classes (PRIETO JIR, 2002). As paper became more accessible, the folding technique expanded and spread, significantly integrating into Japanese culture. The ornaments produced through origami became symbols of social distinction, allowing the identification of family class, such as common citizens, samurais, and followers of philosophers.

Although it is an ancient practice, the use of origami in education is relatively recent, and in recent years, many countries have incorporated it into their curricula with the goal of enhancing cognitive development, motor skills, and social interaction (ARICI S e ASLAN-TUTAK F, 2015; MARJI MS et al., 2023). In Brazil, the incorporation of origami as an educational tool has been carried out informally, with some initiatives in the field of mathematics (geometry), psychomotor skills in Physical Education, and science education for three-dimensional representations of molecular structures (FARIAS-DIAS CF, et al., 2019; KISHIMOTO ST, et al., 2014; SEPEL MN e LORETO ELS, 2007).

The versatility of origami as a learning object in interdisciplinary activities is immense, allowing its application in various areas of knowledge. The folds used to create three-dimensional objects provide a concrete approach to mathematical concepts, stimulating logical development, spatial intelligence, imagination, and creativity (WONG Y, 2022; KÖĞCE D, 2020; CHEN K, 2006). Concepts of geometry in both plane and space, comparison of sizes (larger and smaller), and the understanding of fractions can be explored using this technique. In Artistic Education, it allows work with colors, originality, and aesthetics, in addition to encouraging careful execution of activities. In Science education, creating figures of animals, plants, and molecular structures stimulates detailed observation of their key features, helping to represent them faithfully. In Portuguese Language, origami can be used in dramatizations, expanding interaction possibilities and contributing to the development of oral skills and expression (PILLARECK ME e SILVA MRS, 2010). Even in psychomotor activities in Physical Education, origami can help develop fine motor coordination, preparing children for learning to write (KISHIMOTO ST, et al., 2014).

Considering the different nuances and possibilities of using origami in basic education, the goal of this study was to develop an activity focused on geometry, evaluating the behavior of elementary school students in terms of enhancing motor, cognitive, and social skills.

METHODS

The origami folding activity was conducted in two public municipal early childhood and elementary schools (EMEIEF) in Laranjeiras do Sul (PR): Água Verde and Aluísio Maier.

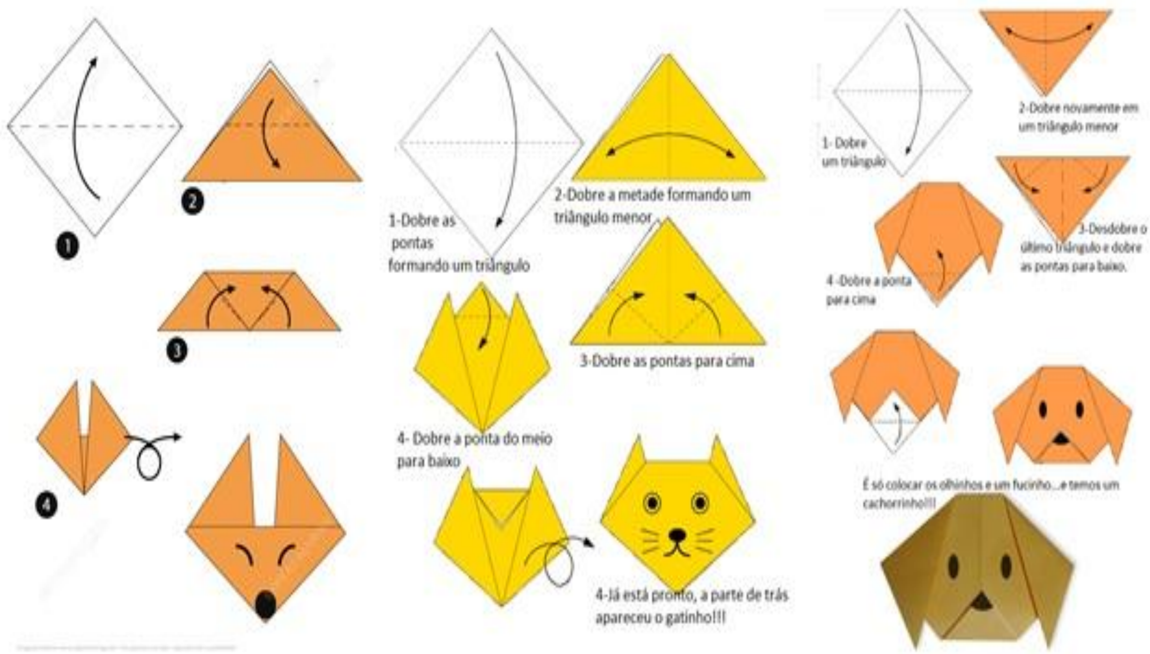
The activity was carried out as part of the Mathematics curriculum with first-year elementary school students, aiming to observe aspects of recognition and translation of plane geometric figures, motor skill levels, cognitive and social abilities, and abstraction in problem-solving situations.

Initially, a bibliographic review was conducted to identify types of folds that could be applied in accordance with the students' age group (6 to 7 years old) and cognitive development. Simple folds were selected, including models of a dog, cat, fox, bear, fish, heart, and cartoon characters. These shapes were chosen to allow the manipulation of two-dimensional forms such as squares, triangles, rectangles, and rhombuses, observing how these forms combine and transform to create three-dimensional figures. Simple folds have the advantage of being quickly executed in the classroom, preventing boredom, distraction, and lack of interest among students, while also fitting easily within the time frame of a curriculum component.

Before each class, planning was carried out to select which type of fold would be applied to assess prior knowledge of geometry, motor coordination, patience, and teamwork interaction. At this stage, the number of materials needed, such as colored paper, rulers (if necessary), and pencils for markings, was calculated based on the number of students.

The activity was introduced with a discussion on the history of origami and its cultural and educational significance, using images to demonstrate the objects that could be created. During the folding process, colored A4 sulfite paper sheets were distributed, cut into 15 x 15 cm squares. The lead teacher demonstrated the step-by-step construction of the three-dimensional object, pausing as needed so that the process could be followed (Figure 1). After the explanation and observation, students were asked to reproduce the created object without the teacher's assistance, to assess their level of assimilation and individual difficulty in executing the task. Group discussions and consultations were encouraged to foster cooperation, and students were individually monitored to provide specific corrections, enabling self-learning, especially for those who showed significant difficulty and became discouraged after multiple unsuccessful attempts.

Figure 1 – Pre-structured origami instruction system on a webpage for creating simple folds: examples of a fox, cat, and dog.



Source: Supercoloring©, 2008-2024.

In order to assess the ability to abstract the technique, students were also asked to fold and unfold the square along one of its diagonals so that the geometric figures made visible by the crease marks could be observed. These marks helped with sequential memorization, as students needed to recall previous folds to reconstruct the object.

In each lesson, students were allowed to personalize their origami by coloring, drawing eyes, and transforming the model into an element of a story, stimulating imagination and creativity.

The analysis of students' reactions to the use of origami and the theoretical presentation of geometric shapes considered aspects highlighted by Celini MJE and Carvalho-Lopes SGB (2008) and Wagensberg J (2000), such as the possibility of manipulation (Hands On), knowledge appropriation (Minds On), and enthusiasm for the activity (Hearts On), as shown in Table 1.

Table 1 - Reactivity variables for assessing the impact of the activity.

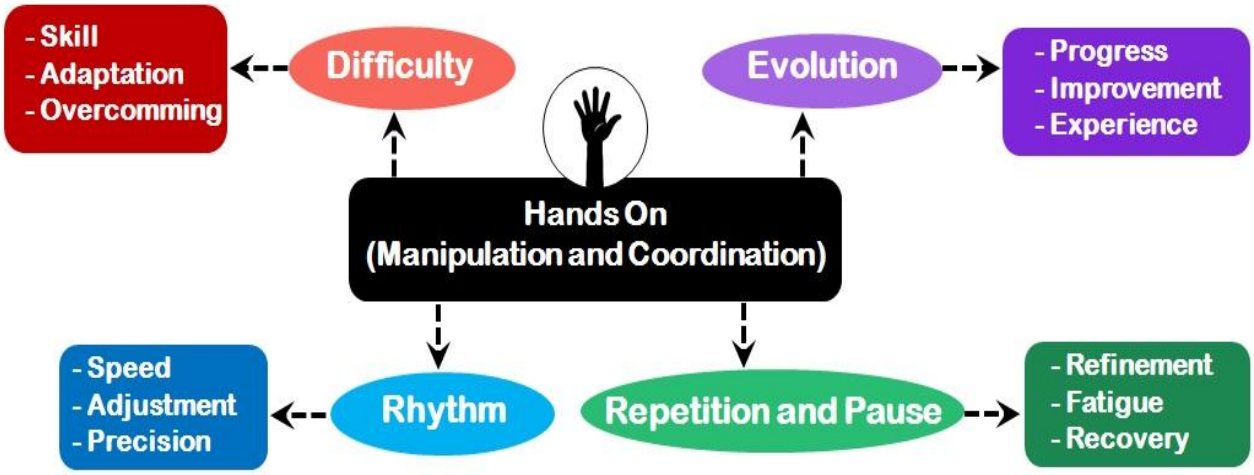
Dimensions	Potential use of origami	Indicators
Hands On • Manipulation • Motor Coordination	• Encourage folding, unfolding, and reconstruction of geometric shapes; • Propose challenges for creating polygons; • Relate the folds to symmetry, angles and fractions.	• Ease or difficulty in performing the folds; • Fine motor coordination of the students; • Ability to recognize mathematical concepts in the created shapes.
Minds On • Learning • Skill Development	• Stimulate reflection on geometric properties in the folds; • Relate the shapes obtained to everyday objects; • Promote discussions on different strategies for forming the figures.	• Students' ability to explain mathematical concepts; • Association between folds and geometric theory; • Curiosity and experimentation beyond what was proposed.
Hearts On • Emotion • Engagement • Enthusiasm	• Create collaborative challenges, such as building three-dimensional shapes; • Relate origami to culture, art, and traditional stories; • Allow model selection to encourage autonomy.	• Level of interest and enthusiasm in the activity; • Creativity and motivation to explore the topic further; • Interaction and knowledge exchange between students.

Source: Monkolski JGF, et al., 2024.

These data were used to create an organizational chart to map whether the information provided was appropriate for the students' cognitive stage, whether additional interesting facts about the topic could be included, and to identify difficulties and perspectives for improving the activity. The organizational charts were constructed based on the expected behaviors for the activity, to guide the observations and facilitate the systematic data collection according to the following considerations:

Hands-On Organizational Chart – designed to gather information on persistence, satisfaction, interaction, frustration, and divergences within the process of manipulation and motor coordination with the learning object (Figure 2).

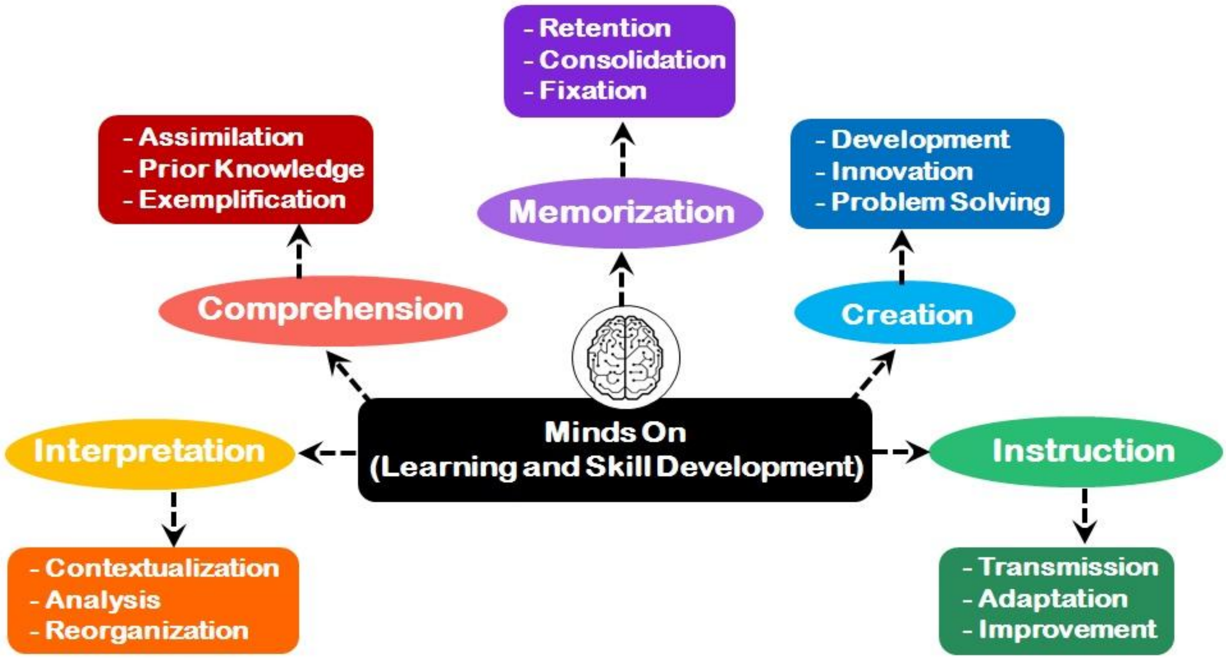
Figure 2 – Organizational chart for recording behavioral information on the manipulation of the learning object and motor coordination.



Source: Monkolski JGF, et al., 2024; Icons PNG-egg, 2024.

Minds-On Organizational Chart – designed to gather information on comprehension, memorization, creation, interpretation, and instruction behaviors within the learning and skill-building process with the learning object (Figure 3).

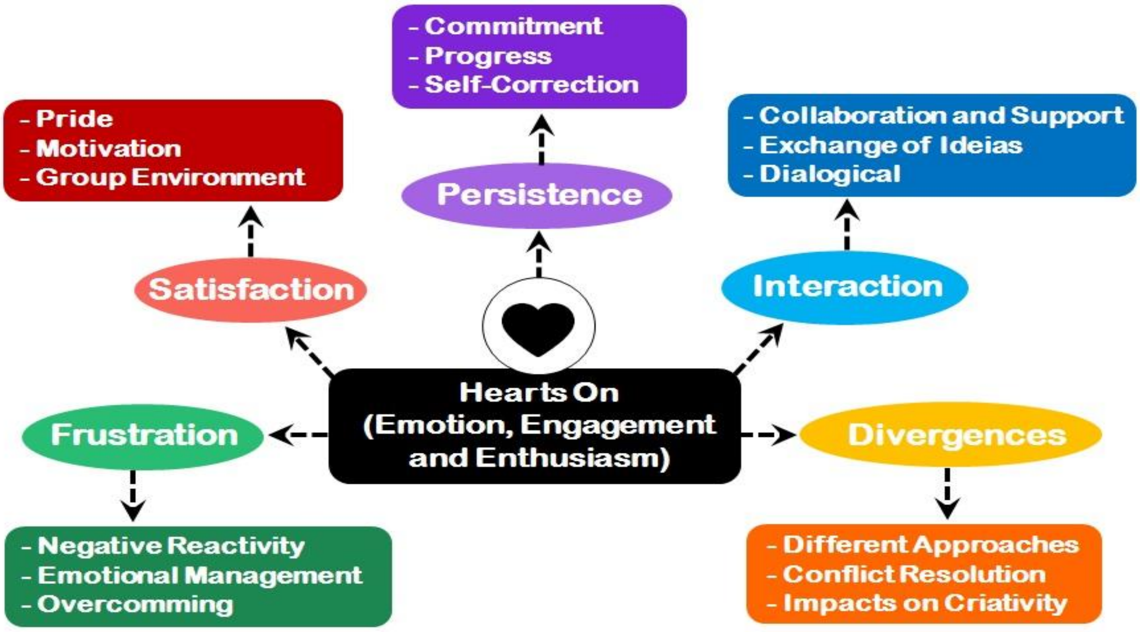
Figure 3 – Organizational chart for recording behavioral information on learning and skill-building with the learning object.



Source: Monkolski JGF, et al., 2024; Icons PNG-egg, 2024.

Hearts-On Organizational Chart – designed to gather information on satisfaction, persistence, interaction, frustration, and divergences within the emotional process, engagement, and enthusiasm with the learning object (Figure 4).

Figure 4 – Organizational chart for recording behavioral information on emotions, engagement, and enthusiasm with the learning object.



Source: Monkolski JGF, et al., 2024; Icons PNG-egg, 2024.

At the end of the fourth week of the activity, a semi-structured questionnaire with simple questions was applied to assess the level of knowledge assimilated based on the proposed use of origami, organizing the questions into the categories highlighted in Table 2.

The results were compiled to produce an experiential report with a qualitative approach, presenting a critical analysis of the practices and interventions, accepting the experience as a starting point for learning (MUSSI RFF, et al., 2021). Considering the multiplicity of theoretical and methodological options inherent in this type of production, we sought a descriptive, interpretative, and comprehensive approach to the events experienced, respecting their insertion in a specific historical context (DALTRO MR and FARIA AA, 2019). Thus, the experience is not only narrated but also analyzed in its complexity, allowing not only the systematization of findings but also a critical deepening of the challenges and possibilities identified.

Table 2 - Organization of the semi-structured questionnaire for activity assessment.

Categories	Focus of the Approach	Questions
• Geometry and Shape Recognition	• Identification and differentiation of geometric shapes, exploring concepts of sides, angles, and properties of figures.	• Which and how many geometric shapes did we form? • How many sides does this geometric shape have? • Are these sides the same or different? • What is the difference between a square, a rectangle, and a triangle? • How many triangles did we form? • What are the sides of these triangles like?
• Relation to the Real World and Abstract Thinking.	• Knowledge transfer, stimulating the perception of geometric shapes in the environment and promoting connections between mathematics and the real world.	• Is there anything in nature that has these shapes? • Is there anything in your house, at school, or in the classroom that has these shapes?
• Cognitive Processing and Reflection on the Activity.	• Metacognition, that is, reflection on the learning process itself, encouraging visual perception and the organization of spatial thinking.	• Was it difficult to find the flat shapes in the marks left by the folds in the paper?

Source: Monkolski JGF, et al., 2024.

RESULTS

1. Hands On (Manipulation and Motor Coordination)

During the practical folding activities, an initial difficulty was observed among the students in making the folds with precision. Some children showed frustration when they couldn't fold the paper correctly on their first attempts, so additional encouragement was provided to keep them going. Many faced challenges in handling the paper, especially when positioning and folding it in a way that formed the desired angles and shapes. A clear example of this was the difficulty in correctly positioning the paper to form the rhombus, with one of the vertices pointing upward, or folding along the diagonal to join the upper and lower vertices proportionally. This revealed the need for greater fine motor coordination, particularly in applying the folding sequences that require manual dexterity.

Another important observation is that the application of the object showed how different and varied the motor learning rhythms were, which reflected the need for slow and repetitive demonstrations. While some children quickly acquired the necessary skills, others required closer monitoring throughout the activity. It was evident that a significant percentage showed deficiencies in psychomotor skills, but these motor difficulties were overcome, with greater precision in the folds as the processes became repetitive. The execution of the folds became increasingly quick and secure, showing the acquisition and/or improvement of motor skills (Figure 5).

Figure 5 – Folding process for training motor skills and fine coordination.

Source: Monkolski JGF, et al., 2024.

The activity highlighted how repetition plays a fundamental role in both the development of motor skills and the understanding of geometric concepts. Constant practice allowed movements to become more automatic and autonomous, enabling the internalization of steps, which made the execution more fluid and less dependent on external instructions. This memorization not only contributed to the correct execution of the origamis but also helped students develop a deeper understanding of the relationships between different stages. By repeating the folds, they began to recognize geometric patterns and understand how the concepts apply to the physical world. This provided concrete learning, where theory is assimilated through action.

The trial-and-error process helped develop resilience and persistence, important characteristics in learning any skill. The satisfaction of successfully completing a fold after several attempts reinforced motivation and interest in the activity. Repetition of the folds did not limit creativity; rather, it provided a solid foundation upon which the children could explore new ideas, combine geometric shapes, and develop their own innovations.

2. Minds On (Learning and Skill Development)

From the perspective of learning, the students showed a growing understanding of the mathematical concepts underlying the folds (Figure 6).

Figure 6 – Learning process of geometric shape recognition through the use of folding techniques.

Source: Monkolski JGF, et al., 2024.

Initially, many were unable to associate geometric shapes with their representations in origamis, indicating a gap in theoretical understanding. Some children showed difficulties in understanding commands solely through the teacher's oral explanation, making repetition and reinforcement of the theoretical concepts involved in folding necessary. However, over time, it was possible to observe an improvement in the students' ability to associate the folds with geometric theories such as symmetry, angles, and proportion. Curiosity also stood out, as many students began experimenting and exploring beyond the provided instructions, creating their own variations and shapes, which highlighted their engagement with the learning process.

The association between the folds and geometric theory was reinforced with the application of origamis, providing a clearer understanding of geometric figure concepts. The ability to explain mathematical concepts was improved, particularly in relation to symmetry and proportions. Curiosity and the desire to expand learning beyond what was initially proposed were also noticeable, as some children managed to develop different models or personalize their creations.

3. Hearts On (Emotion, Engagement e Enthusiasm)

The emotional aspect of the activity was remarkable, with students showing great enthusiasm and motivation throughout the origami sessions, especially during the final moment of the activity with the process of personalizing the learning object (Figure 7).

Figure 7 – Interactions with the learning object and the personalization of the origamis.

Source: Monkolski JGF, et al., 2024.

Despite the initial difficulties, the interest in the activity remained high, and many were visibly committed to overcoming the obstacles. The excitement was particularly evident when they successfully completed their origamis, with expressions of satisfaction and pride in the work done. Additionally, there was a constant interaction between peers, where children who had more ease with the folding techniques helped those who faced more difficulties, creating a collaborative learning environment.

The use of origami as a technique demonstrated that the level of interest and excitement remained high, with students feeling motivated to continue the activity and explore new models throughout the following weeks. Each new week, the lead teacher was asked about the continuation of the origami task.

During the execution of the folds, students voiced doubts, shared strategies, and even created stories about the models they made. The exchange of knowledge and mutual support among the students became evident, with origami fostering a cooperative learning environment and allowing the collective progress of the class. As they developed their own shapes and solutions for the folding challenges, and shared these strategies, new perspectives emerged for applying more complex folds with different objects.

DISCUSSION

The motor difficulties and lack of manual skills detected in this study were also reported by Kishimoto ST, et al. (2014), who analyzed the influence of teaching the origami technique on the fine motor coordination development of children aged 5 to 6 years. According to the authors, at the beginning of the activities, many children struggled to fold the paper in a way that kept the creases sharp to mark the folds. However, over time, these details were assimilated by the children, significantly improving the result of their folds and positively influencing the development of fine motor coordination.

Fine motor skills can be defined as the coordination of small muscle movements in the fingers and hands, usually in coordination with eye movements. The development of fine motor skills is crucial for a child's independence, such as in daily activities, basic self-care, and academic development (FABER L, et al., 2024). These skills are achieved through the maturation of the central nervous system and specific motor experiences explored throughout the child's life (DEHGHAN L, et al., 2017).

The activity of folding and shaping the paper into a specific form requires good fine motor coordination, which is the ability to control the movements of the fingers in a coordinated and precise way. Studies have shown that the practice of origami in children allowed them to learn how to handle the paper with care and precision, as well as develop sensitivity to delicate and subtle movements, significantly improving fine motor coordination (MARJI MS, et al., 2023; ANISA AN, et al., 2021; HARSISMANTO J, et al., 2021).

Another relevant factor is that the origami activity can be an important pedagogical resource when used with children in the literacy phase, as in the present study. In this phase, children need to develop motor skills to trace cursive letters and write, and the practice of origami could positively assist in this process. According to Pradipta RF and Dewantoro DA (2019), by improving fine motor skills, origami activities can also help students in other areas, such as writing, drawing, and performing tasks that require delicate and precise finger movements. Therefore, the use of origami in education can help improve students' overall fine motor skills.

Regarding geometry education, this study demonstrated that origami is an excellent tool to observe and identify the presence of plane figures in the construction of paper folds, autonomously giving more meaning to their learning. This condition would not be achieved in traditional teaching, where students are required to accept this information passively and often without any correlation to their daily lives. Thus, introducing origami into the classroom can impact improving students' performance in mathematics (NDUBISI EE and AROKOYU AA, 2022).

The work of Unodiaku SS (2022), with secondary school students, clearly demonstrated that after incorporating origami activities into the mathematics curriculum, student interest and acceptance of the subject significantly increased. The author also concluded that students who used the origami-based instructional model had higher average scores compared to those taught with the conventional method. In the investigations by Bornasal JP, et al. (2021), it was inferred that the activity of folding and shaping paper into geometric forms helped students better understand the relationship between geometric shapes and recognize basic properties such as angle, side, and symmetry. According to the results, the performance of students in mathematics exposed to paper folding teaching was significantly better ($p \leq 0.001$) compared to those taught without folding, with mean scores of M= 21.40 and M= 14.42, respectively.

Research conducted by Ndubisi EE and Arokoyu AA (2022) revealed that, in the experimental group of young students who learned about geometric solids with origami-based instructions, there was a higher average performance gain compared to students who were instructed only through graphs, with a significant difference ($p \leq 0.05$) between the performance of students in the two approaches studied. Therefore, these results reinforce that the use of origami in teaching geometry has positive effects on learning and student performance, as this art helps students visualize geometric concepts in a concrete and easy way.

Many of our everyday skills are determined by a certain step-by-step sequence, such as tying shoes. Building an origami also consists of performing a series of actions following a specific sequence (ZHAO F, et al., 2020). In this study, while folding and unfolding the paper during the construction of the origamis, students noticed the need to memorize the sequences of these folds in order to complete their shapes. According to Marji MS, et al. (2023), origami also teaches students to follow a sequence of steps in a certain order, which helps develop logical reasoning, visuo-motor coordination, concentration, and problem-solving skills.

Among the many benefits that incorporating origami into the classroom can bring, there are also positive effects on students' psychology and emotions, reducing stress and anxiety and improving social skills. Studies conducted with hospitalized children revealed that origami was effective in reducing anxiety and stress, even reducing the use of medication and aiding in the recovery process of patients (ISLAM R, et al., 2019; HELENA N and SHARMILA P, 2019; THAPA J, 2024).

During our activities, it was possible to observe that students demonstrated more commitment, dedication, and concentration. In addition, they had the opportunity to develop social skills such as teamwork and a sense of empathy by helping a peer with difficulties.

CONCLUSION

The practice of origami has proven to be an effective educational tool in elementary education. Initial motor difficulties were overcome, resulting in significant improvements in students' fine motor skills. Additionally, the activities involving paper folding facilitated the understanding of geometric concepts and encouraged the memorization of sequences. The use of origami also promoted the development of social skills, such as teamwork and empathy, creating a dynamic and engaging learning environment. Previous studies support these findings, indicating that origami can improve fine motor coordination, academic performance in mathematics, and students' social skills. Therefore, the results of this study suggest that incorporating origami into the school curriculum can bring various benefits to students' overall development, reinforcing the importance of teaching methods that integrate playful, cognitive, and social aspects. Origami, with its ability to engage and educate creatively, presents itself as a valuable pedagogical tool for elementary education.

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