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The Influence of Origami on Spatial Abilities in Mathematics Learning

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ABSTRACT

The essential mathematical ability related to geometric perception is spatial ability. Through this ability, one can develop geometric reasoning abilities in everyday life. In some literature, spatial ability is closely related to various applied fields in life. One way to develop and hone this ability is through the art of origami paper folding. In several studies, it has been found that origami can enhance students' spatial abilities at various educational levels. Origami is the art of folding paper that is utilized for teaching basic geometric shapes through folds that form simple structures, which can serve as a bridge for students to understand how the objects they fold are formed. This origami folding can be used to train and enhance the spatial abilities of students from various educational levels. Teaching origami can foster and develop students' enthusiasm in learning mathematics, especially geometry. Origami has a positive correlation with mathematics learning outcomes in the classroom, particularly regarding geometry topics.

Keywords: mathematics education; origami; spatial ability

INTRODUCTION

Rogers in P. I. Wardhani et al (2020) defines creativity as the tendency to express and activate all of a person's abilities, to mature, to realize potential, to develop, and to express all the abilities of an organism. Coghlan in Ilhami (2022) explains that craft art is an artistic activity that encourages children's creativity. Handicrafts help parents and caregivers build relationships with their children and support their creative development. According to several experts, handicrafts are a type of constructive play where children use various materials or media to transform objects or create specific artworks. The process of making handicrafts requires manual skills, and the media or materials used in constructive play are natural materials such as paper (Ilhami, 2022).

Amstrong in Anwar (2019) identifies eight types of intelligence: logical-mathematical intelligence, musical intelligence, linguistic intelligence, spatial intelligence, naturalistic intelligence, bodily-kinesthetic intelligence, intrapersonal intelligence, and interpersonal intelligence. The ability to see geometric shapes falls under spatial intelligence. This ability is related to geometric shapes such as flat buildings and spaces. Shape is the earliest concept that children must learn. This is because they have the ability to distinguish objects based on their shape rather than other features. Sorting can also mean arranging something in a specific order; for example, five sticks arranged from the shortest to the longest. The orientation of an object or image greatly influences its perception, and this is reinforced by this. In origami, Giaquinto (2007) states that spatial intelligence is necessary to correctly recognize objects or images (D. Wardhani & Bambang, 2016).

Visual-spatial intelligence is defined as the ability to recognize what is seen around, manipulate things based on perceptions of things, and create and design something referring to experiences gained through the visual of real objects and imagination (Gardner, 1999). Visual-spatial intelligence is the ability of an individual to identify and recreate visual images that are identical to objects by utilizing their sensitivity to concepts of color, shape, size, and space. The opinions of the experts above support this conclusion. Drawing, sketching, organizing and designing, playing constructively and creatively, and creating artwork are some ways preschoolers can enhance their visual-spatial intelligence. (Ilhami, 2022). The ability to imagine one or more objects and visualize them as two or three-dimensional images to be used for solving related problems is called spatial ability (Rahman, Hadisaputra, Supriadi, & Junaidi, 2022). One type of spatial intelligence is the ability to accurately identify colors, directions, and spaces. The ability to perceive and manipulate the visual world without physical stimuli is the foundation of spatial intelligence (D. Wardhani & Bambang, 2016).

Spatial intelligence can be applied in various fields. Indragiri (2010) states that teachers can help children develop new ideas and use their imagination and innovation to solve everyday problems by enhancing their visual-spatial intelligence. As a result, visual intelligence needs to be developed and stimulated. Students must have good visual-spatial abilities if they want to enter science majors, such as biology (Uttal & Cohen, 2012). This is due to the fact that most scientific objects cannot be directly observed. Students can internalize relationships such as the shape of DNA, photosynthesis reactions, human respiration processes, etc., by using their visual-spatial abilities. (Hidayat, Halifah, & Zainuddin, 2022).

Some unusual things that children do are signs of intelligence in children, and the strange behaviors exhibited by children may be signs of special intelligence. According to Gardner and Armstrong in Oktavia (2014) the ability to solve problems and produce works in a rich and naturalistic environment is more often associated with intelligence. (Maula, 2015). Wardhani (2016) said origami is not only a tool for spatial abilities improving but also helps students understand geometric concepts in mathematics.

RESEARCH METHODS

The writing method in this article is a literature review, which is the result of a study of several previous research in some references which is related to spatial abilities and origami. It also draws conclusions from previous research on the application of origami and its implementation in spatial abilities in mathematics learning, especially in the field of geometry.

RESULTS AND DISCUSSION

Research shows that origami can be used as a tool for learning mathematics.. (Boakes, 2008; Cakmak, 2009; Pearl, 2010; Sze, 2005). Pearl (2010)) also states that origami can be used in all aspects of mathematics, including problem-solving, measurement, geometry, fractions, and spatial visualization (Susanti & Rosyidi, 2009).

Figure 1. The Origami and Colored Paper Used

Benefits & purposes of origami

As is known, Cornelius and Tubis state that origami, which is the art of folding Japanese paper, has the potential for teaching mathematics, especially geometry. (Gür, 2017). Can be used to reinforce the shape in the first origami. Students discover the shape after each fold. (Shoup, 2009). By making origami, you can improve your shape recognition. Children can recognize the shape of the paper each time they fold it. In addition, children can learn about various origami shapes and become creative. Playing origami can help you understand various concepts. This will discuss geometric shapes such as circles, triangles, or rectangles (Ilhami, 2022).

Making origami regularly is also a concentration exercise and can help children improve their concentration span. This is necessary if origami is done regularly and starts with the simplest models, gradually increasing in complexity according to the child's abilities. One additional benefit is a stronger visual and spatial perception. Children will learn more about animals and their environment because we can choose origami shapes and use them as tools. To encourage school-aged children to acquire the skills and competencies necessary for daily life, folding specifically aims to enhance memory, observation, manual dexterity, creativity, precision, neatness, and a sense of beauty (Lady Diana Yusri, Adrianis, Aulia Rahman, 2019).

Uswatun Hasanah dan Priyantoro (2019) also conducted research on the development of origami media for the creativity of early childhood. Additionally, the research conducted by Muhammad Rusdi Tanjung and Parsika (2017) on the development of origami as the art of paper folding has enhanced knowledge and aesthetics. The activity of folding origami can help students become creative, which in turn impacts their thinking process in learning. (Putri Rahmawati, 2022). To support the learning process, origami learning media must be used (Muhamad Toyib, Alviani Milenia Safitri, 2022).

Through activities such as folding, students can improve their spatial visualization. To achieve this goal, origami-based learning is one of the methods that can be used. There is a possibility that origami is related to mathematics, especially the geometry chapter, based on previous discussions. Because origami involves hands-on activities, it can help students learn mathematics. Origami teaches students to work together and interact with

others. Teachers have used various approaches to help students visualize and mentally process geometric figures. One of these techniques is origami, the art of paper folding. (D. Wardhani & Bambang, 2016). According to Boakes (2008), the experience of making origami also makes students happy. In addition, he stated that origami enhances students' understanding of the geometric concepts and terms they are learning. Therefore, it can be said that origami enhances students' spatial abilities and helps them understand geometric concepts in mathematics. Furthermore, the research by D. Wardhani & Bambang (2016) shows that designing learning activities using origami paper as a medium for spatial geometry materials can increase student participation.

Learning origami is a fun experience for students. Origami is not only fun, but it also offers many ways to teach children mathematics. In addition, it is a creative approach to enhance educational, social, and cultural skills. Early childhood or preschool children are children aged two to six years. Youth is called the golden age. According to Trisniawati (2018) there are several benefits of the art of origami folding, including:

1) Training children's fine motor skills while also providing a safe, inexpensive, enjoyable, and beneficial way to play.
2) Origami teaches children to make their own toys, which is more enjoyable than ready-made toys bought from toy stores
3) The process of making origami requires perseverance, patience, and discipline to achieve the desired shape.
4) How do children feel when they can make something themselves? Definitely proud and satisfied. Additionally, making origami teaches children to appreciate and value what they create. Learning origami also helps you learn to think mathematically, read diagrams and images, and use the shapes created to make proportions or comparisons.. (Andani, 2015)

Children need an understanding of layout to know the starting point of folds when they make origami figures. The origami instructions they see help them understand the layout and can perform mental transformations through visual imagery. (Victoria, Sahrani, & Patmonodewo, 2019). Studies show that origami has become one of the effective learning methods. According to Books in Annisa (2021) origami has now become a part of mathematics education and innovation in other fields. Moreover, recent research shows that origami can help children become more disciplined, focused, and logical, as well as reduce stress and hypertension in adults.

Stages of Teaching Origami

According to Boakes (2008) origami-based learning design is a small step that can be taken by teachers at any grade level. Furthermore, he states that origami-based learning design requires the following steps: 1) Find origami publications that meet the students' needs (difficulty level and illustration quality); 2) Consider the mathematical concepts and/or vocabulary demonstrated when selecting origami models; 3) Attempt to fold the origami model that has been created. Record vocabulary that aligns with the learning objectives during the trial; 4) Fold the origami model again. At each step, stop and write relevant questions for the teacher from the vocabulary you have previously written; 5) Answer the teacher's questions and write down the expected student responses.

Origami can be used to help young children learn basic mathematics. By using origami, people can learn to think logically, symbolically, and visually-spatially. Learning using origami construction paper is easier, more independent, and results in fewer folds compared to learning using the demonstration method based on steps in the origami diagram. (Respitawulan, 2021). A conventional origami teacher must memorize the sequence of folds that need to be made. Some teachers are afraid to use origami as a teaching aid because they do not know how to read origami diagrams or make origami models in general. They can also learn by looking at photos and videos.

Figure 2. Teaching Origami to Children

According to Nishida (2019) origami is also used to enhance visual-spatial intelligence, especially in distinguishing geometric shapes. Origami paper can be folded into triangular, square, and rectangular shapes adorned with various colors. It has the ability to enhance virtual-spatial intelligence by up to 75%. Demonstrations are usually used to teach children origami.. According to Valentina (2019) the teacher helps the children fold the origami model completely according to the folding sequence. Afrianti in Respitawulan (2021) states that children can make folds in a short time if they are already accustomed to making origami. However, children who are just learning may take longer and might also need the teacher's assistance.

The Usefulness of Spatial Abilities and Their Role

Sipus (2012) shows that spatial ability is very important for students' success in learning geometry. Therefore, spatial ability affects how students learn geometry, especially basic geometry. This study reaches the following conclusion based on previous theoretical discussions and analyses: spatial ability can predict geometry learning ability, which means spatial ability influences students' geometry learning ability; the better the students' spatial ability, the better their geometry learning outcomes. (Hodiyanto, 2018)

Spatial ability is very important for identifying changes in the shape of a building. Therefore, it is highly expected that students acquire this ability so that they can easily understand the relationships and properties of geometric shapes. Spatial ability is very beneficial for communicating about the relationships and positions between objects,

sending and receiving directions, and estimating changes in the position or size of shapes. Studies also show that there is a relationship between spatial perception and general mathematical ability. There is a direct relationship between learning non-geometric concepts and spatial perception (Kusumawardhana, Arnyana, & Dantes, 2020).

Students' spatial abilities positively correlate with their achievements in STEM (science, technology, engineering, and mathematics). Cheng and Mix (2014) say that understanding the relationship between space and mathematics is very important when we are still young. Some studies show that early intervention can reduce the rate of math failure (Victoria, Sahrani, & Patmonodewo, 2019). Atmajaya in Maula (2015) states that the information taught in schools only enhances certain abilities and focuses more on the functions and roles of the right hemisphere of the brain, thus not improving the intellectual development of children. Spatial abilities can change the roles and functions in the right hemisphere of the brain.

Characteristics of Spatial Intelligence

One of the characteristics of visual-spatial intelligence in children is their love for shapes, space, colors, and images. This is reinforced by the fact that children who enjoy playing with shapes and spaces can memorize street names from the routes they take, participate in creating things related to space, possess good problem-solving skills, and enjoy measuring objects accurately (Indira, Murnaka, Haryanti, & Paduppai, 2023). Spatial ability does not depend on the level of education or class (Dianita, 2021).

From early childhood to higher education, spatial abilities can be developed. According to the research conducted, there are at least six ways to enhance spatial abilities in mathematics learning at school: (1) using spatial language in daily interactions; (2) teaching sketches and drawings; (3) playing suitable games; (4) using tangrams; (5) playing video games; and (6) making origami and paper folding. (Sudirman & Alghadari, 2020). Research conducted by (2016) found that origami can help students participate in math tasks, especially geometry. This can help students improve their spatial intelligence due to its connection with images and shapes. According to Brückler (2017)), the relationship between origami and mathematics includes: 1) origami polyhedron and polygon models; 2) analogous axiomatic approaches; and 3) dimensional analysis for folding models to a specific size. Geometry shows the relationship between origami and mathematics, and perhaps origami can be used as a tool for teaching mathematics in Indonesia. (Muhamad Toyib, Alviani Milenia Safitri, 2022)

The relationship between origami and mathematics is established by setting several axioms in origami. According to Lin, Chen, and Lou in Putri Rahmawati (2022) using difficult books can enhance spatial abilities. In fact, spatial ability in learning is still considered less important. As a result, spatial intelligence must be trained and supported through new learning innovations. (Indriani, 2018). Origami-based learning is a learning process that involves folding origami paper as a medium (2014). Students' creativity can also be enhanced with origami-based learning. According to Toyib & Ishartono (2018), origami can even be used to improve mathematics teaching methods in high schools. Therefore, new learning methods that support spatial intelligence, such as origami, are necessary. Wardhani (2016) said origami is not only a tool for spatial abilities improving

but also helps students understand geometric concepts in mathematics. Although the method has distinct effects on the spatial abilities of males and females, origami courses integrated into mathematics training are just as helpful as standard instruction in developing a comprehension of geometric words and concepts (Boakes, 2009).

CONCLUSION

Origami can be a tool for spatial abilities improving but and helping students understand geometric concepts in mathematics. Although the method has distinct effects on the spatial abilities of males and females, origami courses integrated into mathematics training are just as helpful as standard instruction in developing a comprehension of geometric words and concepts. Origami can also be used to train and enhance the spatial abilities of students from various educational levels. Teaching origami can help students become more interested in learning mathematics, especially geometry. Origami has the potential to enhance students' spatial abilities, which are important in mathematics and useful in real life. The teaching of origami is still hindered by instructors who lack mastery of the folding stages in the process of shaping the objects. This can serve as a reflection point to enhance the efforts in introducing origami along with its steps in the future.

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