ORIGAMI

Origami is broadly defined as the Japanese art or technique of folding paper into decorative shapes or figures. The words originate from the Japanese “ori,” meaning to fold, and “gami,” meaning paper. Origami involves carefully folding square sheets of paper to transform them into detailed models depicting shapes or animals.

Origami is unique as an art form because it is neither additive nor subtractive; the artist begins with a piece of paper and ends with the same piece of paper, only changing the paper’s “memory” using folds. In painting or drawing, new material is added to a canvas. In sculpting, the material is both added and subtracted during the process. The inherent limitations of origami have been a significant challenge artists need to overcome as model designs have become increasingly complex. These difficulties have forced prominent origami artists to integrate mathematical concepts into their designs to achieve the level of detail they desire.

As such, origami is in an extraordinary position as a form of educational art with many advantages over other mediums. The innate mathematics of origami designs scale exceptionally well throughout the K-12 curriculum, from basic shapes and angles to calculus and complex theorems. In addition to mathematical concepts, origami builds many additional skills, including but not limited to spatial reasoning, hand-eye coordination, patience, memory, sequencing, fine motor control, and mental concentration. In my project, I will be focusing on the benefits of developing spatial reasoning at a young age in an elementary setting.

SPATIAL REASONING

The link between spatial reasoning and success in mathematics has been well established through rigorous research. (See Figure 1) Four explanatory mechanisms that link numerical competencies to spatial visualization skills were found by Hawes & Ansari, 2020:

• Spatial representation of numbers
• Shared neural processing
• Spatial modeling
• Working memory

These systems are proposed to work in tandem with one another, giving rise to stronger spatial-numerical associations, thus promoting increased mathematical achievement in students.

It is critical for educators to recognize the meaningful role spatial reasoning along with mathematical modeling plays in the overall development of mathematical skills and conceptual understanding. Many students have trouble understanding concepts without being able first to perceive a visual image of the idea in their mind (Arwowd & Kaultz, 2007). Mathematics curricula overloaded with abstract ideas and symbolic representations compel students to memorize procedures, denying them the chance to utilize their visual reasoning in the process of making new connections and building conceptual understanding. Origami serves as an unlikely bridge between artistry and mathematics, serving as an art form, visual/physical manipulative, and real-world context for problems all in one, promoting connections and effectively supporting multiple means of instruction.

SPATIAL REASONING IN MODERN CURRICULUM

Unfortunately, spatial reasoning is rarely taught explicitly or assessed through our curriculum and standards. In modern schools, curricula and tests are mainly suited to students who excel in verbal and mathematics reasoning. The missing element in teaching and education policy is the teaching, measurement, and assessment of students’ individual strengths in spatial reasoning. Spatial ability is often treated as an afterthought in instruction and the common core standards, being taught indirectly using various manipulatives and examples.

ORIGAMI-BASED INSTRUCTION

In the classroom, Origami-based mathematics lessons combine the ancient art of paper folding with mathematics instruction. The inherent mathematics within origami lends itself to hands-on lessons that allow students to develop spatial reasoning, work through contextual math problems, and have fun creating an artistic paper figure. Origami performance and success is directly tied to an individual’s spatial reasoning performance. (Hanada, 2021) In other words, spatial reasoning is required for students to succeed in origami, supporting the idea that origami can be used to develop spatial reasoning successfully.

Surprisingly, Origami-based mathematics lessons are as beneficial as traditional instructional methods in teaching mathematics. A study conducted by Norma Boakes found that even when substituting formal math instruction for 1 hour of origami instruction each week, math achievement scores remained unchanged. (Boakes, 2009) In a similar study, origami-based instruction was found to have a statistically significant effect on students’ spatial ability scores, as seen in figure 2 below. (Cakmak et al., 2013)

Studies also indicate that student tend to develop positive attitudes towards origami-based instruction. Participants self-reported their opinions about origami-based instruction, describing it as enjoyable, entertaining, or beautiful. (Cakmak et al., 2013) Additionally, most of the students wished to continue the origami-based instruction in the succeeding years of their education, which further indicates their positive opinions. (Cakmak et al., 2013) These findings were supported in the study by Boakes (2009), in which the students similarly reported that origami-based instruction was helpful and enjoyable.

CONCLUSIONS

Origami-based mathematics lessons are as effective as traditional instructional methods in teaching mathematics. In addition, there is a significant positive effect from origami-based instruction on elementary students’ spatial reasoning and spatial visualization ability. Moreover, students tend to have a positive attitude toward origami-based instruction and actively wish to continue learning through origami-based education in the future. Furthermore, while students commonly encounter folding and assembling difficulties, they are able to overcome these difficulties by themselves, with the help of the teacher, or with the help of their friends. All research points toward origami as a naturally hands-on approach to teaching mathematics while promoting spatial reasoning. The fact that origami is such a hands-on activity lends itself to discovery-based lessons emphasizing active learning. With the strong links between origami, spatial reasoning, and mathematics ability, one could argue that it is impossible to fold origami without mathematical learning taking place.