The Enjoy Origami on Mathematics and Science Education in STEAM

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***Abstract**: The origin of Japanese origami culture came from the Ancient China as the Buddhist tradition (around the 6th to 7th centuries). Especially, the paper on which the Buddhist scriptures are written is the root of thin and durable Japanese paper. Washi, called very traditional Japanese paper, is still used in various places even in modern Japanese society. Origami paper is very popular for young children in primary school in Japan. Therefore, origami is great material for mathematics education. In Japanese mathematics education, using origami as a teaching material that is very familiar to children stimulates not only children's intellectual academic ability but also emotional aspects, and is improving the educational effect. For example, in Euclid geometry, angle trisection and doubling problems are famous as impossible to draw on mathematics, but it is possible by using origami. Similarly, the problem of drawing with a ruler and compass can be easily drawn by children using geometric PC software; GeoGebra, Grapes, Cinderella, etc. By using origami and geometric software in combination, children can expect more effective mathematics education than ever before. On the STEAM, why don't you go on a fun geometry learning journey with your children and math teachers using origami?*

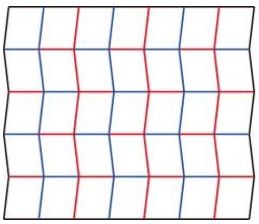
1. Introduction

This paper is a continuation of our studies of enjoy mathematics using geometric PC software; GeoGebra, Grapes, Cinderella, etc. plus hands-on Origami. Previously, in Project Origami (2013) and Quadrivium(2010) we explore Origami culture in Japanese everyday life.

One of the traditional Japanese lifestyles is the culture of folding things which related to Origami paper. For example, Japanese traditional *futon* is folding like a mattress and storing it in a cabinet (*Oshire*; closet).

There is a culture of saving space by using it as a living room during the day and as a bedroom at night. This example is also applied to space utilization of the International Space Station (ISS: About 400 km above the ground, a huge experimental facility floating in space development). Also, when loaded into a rocket, it can be folded into a small size for storage, and in outer space, the solar panel can be unfolded for use. In the limited space of the current ISS, using the idea of partition panels like Japanese *shoji* and *fusuma*, one space can be divided into various spaces by inserting and removing partitions. The purposeful use lies in the wisdom of life in the Japanese way of life which originated by Origami culture.

Another example, just like the idea of an umbrella that can be opened with a single touch, it is an application example of space development technology, such as a solar panel that can be opened and closed with a single touch, which became famous for the development of *Miura Ori*.

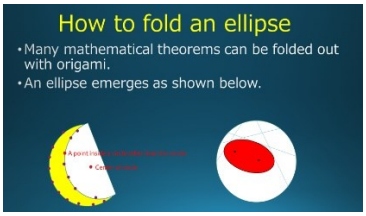


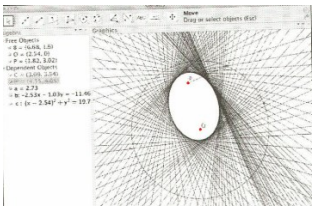
Behind this idea is the wisdom of origami as a traditional Japanese culture. I believe that the wisdom of this origami can be used as a catalyst for mathematics and STEAM education.

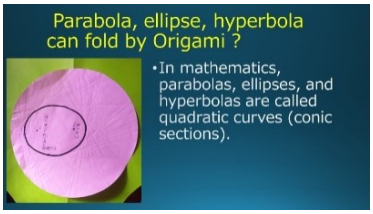
2. The Origami paper is useful and effective material in STEAM

As an example of a math lesson using origami, each student will first check on their computer screen that they will draw diagrams of parabolas, ellipses, and hyperbolas using the geometry software GeoGebra, Grapes, Cinderella, or etc. Next, about the trajectory of the tangent line of the conic curve similar to the PC screen, using origami, I folded each line with my own hands, and many tangent lines were the same as the PC screen. Finally, we can see the meaning of eccentricity in conics (that planetary orbits are elliptical).

Since ancient Greece, many origami enthusiasts around the world have already proposed ways to solve the three famous unsolved problems of geometry (only use ruler and compass) with origami. I will challenge students to understand the content with basic knowledge of geometry (similarity, congruence, proportionality) at the junior or high school level. Using origami, each student will challenge themselves to "trisect an angle," "double the problem," and "construct a circle with the same area as a square." For example, here is an example of trisecting an angle of less than 90 degrees, as follows;







Also, the method of determining one side of a double product of a cube is one of the excellent methods for geometrically understanding the meaning of the cube root.

Finally, regarding the relationship between geometry and musical harmony, geometry is primarily a way of representing space. On the other hand, I would like each student to realize that music is a way of expressing harmony with time, and that both have the potential to be expressed with origami.

3. Future Possibilities of Origami and Mathematics and STEAM Education

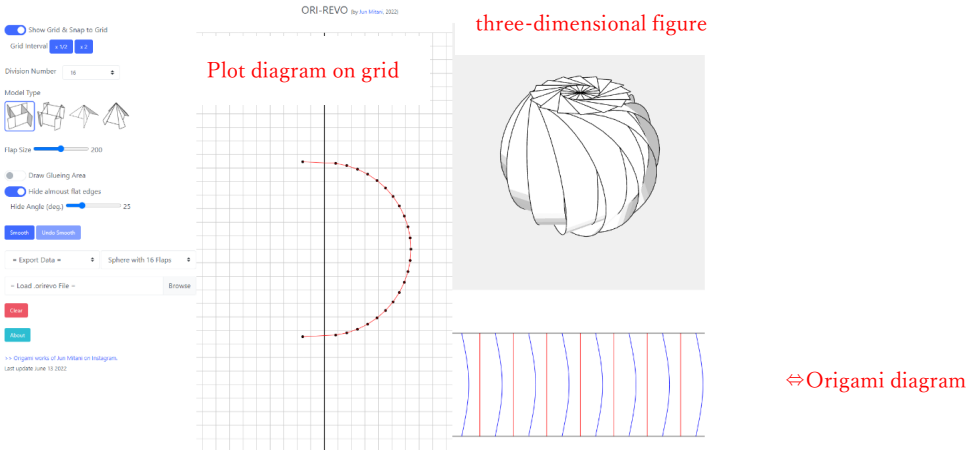
One of the main attractions of using origami to teach math is that it requires hands-on participation. There's no chance of someone hiding in the back of the room or falling asleep when everyone is trying to hold a hyperbolic paraboloid. The fact that origami is, by definition, hands-on makes it a natural fit for active learning. One could even make the argument that while folding paper, especially when making geometric models, latent mathematical learning will always happen.

When choosing to use origami as a vehicle for more organized mathematics instruction,

an easy choice is to let the students discover things for themselves. This approach to teaching mathematics is allowed to experiment and discover basic principles and theorems, was pioneered by Henderson (2001) in college-level geometry courses. The approach is based not only on exploration but also in students learning how to ask the right questions while exploring.

Open-ended assignments arise from not knowing how to ask questions. The value of the discovery-based approach should be clear, in that it provides students with the experience of being a mathematical researcher.

Finally, I would like to introduce Jun Mitani, who is a professor at the University of Tsukuba in Japan, has developed software for origami ORI-REVO (tsukuba.ac.jp) and is making it available to the general public. Like GeoGebra, Grapes, and Cinderella, children and adults can experience origami art for free. A lot of similar origami software are open to the public in Japan. It is now possible for math teachers to make good use of the origami software and learn mathematics, geometry, and space engineering while actually folding origami. I think that it will play a part in STEAM education in the future more.



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[2] Henderson, D. (2001). *Experiencing Geometry in Education, Spherical, and Hyperbolic Spaces, 2nd ed., Prentice Hall.*

[3] Mitani, J. (2022). https://mitani.cs.tsukuba.ac.jp/ori_revo/ or ORI-REVO https://mitani.cs.tsukuba.ac.jp/ja/software/orirevo/