**The Foldable Mathlete: Bending Mindsets through Origami**



Lesson #1 From 1000 Paper Cranes to Stellar Scopes

Lesson #2 Fullerenes - The Biggest Guy on the Block

Lesson #3 Small Size Save Lives

Lesson #4 To Boldly Fold where no one has Folded Before

Feel like you have the power to change the world with your terrific ideas and artistic expressions? This is the course for you! As a foldable mathlete, you will learn how through the ancient art of origami to solve engineering dilemmas, build a better building, and creatively solve medical problems using nanobots you design. Influence and share and your problem solving origami creations with the professionals in the field of engineering, architecture, and medicine.

In what ways does the ancient art of origami illustrate power in contemporary design and innovation?

Yvonne Maisel de St. Croix & Beth Laughridge

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Intelligence, Designed:

The Importance of Teaching Origami to the Gifted and Talented

I. Introduction

Joseph Renzulli developed the three-ring conception of giftedness. His definition entwines above-average ability, task commitment, and creativity as seen as three interactive clusters of traits that gifted students may exhibit or are capable of developing. Through the ancient art of origami, these traits may be cultivated in gifted and talented student populations. Manipulation of paper enhances metacognitive development of students they address real world applications. Simultaneously, the kinesthetic incorporation of origami enhances and prolongs understanding of mathematic, scientific, and engineering principles.

Paper, invented in China in 105 A.D., was transported by monks to Japan around the 6th Century and consequently, paper folding began. Handmade paper was too expensive for an average person, so having the ability to participate in paper folding was a luxury and initially used for religious ceremonial purposes. Beginning in 1603, at the start of Edo Period, it is documented that paper folding in Japan became ceremonial *and* recreational, and a new art form was founded. Paper folding in Japan had become an extremely popular pass time. Written instructions for paper folding first appeared in 1797 in the book *Sembazuru Orikata*, or “thousand crane folding,” written by Akisato Rito. In 1845, Adachi Kazuyuki published a more broad compilation of paper folding. During the late 1800’s, is when the term “origami” was officially introduced, replacing the term paper folding or “orikita.”

Origami has always been a pastime and an art form for many people. Akira Yoshizawa is considered a founding father of modern origami. He created many modern patterns of folding origami using a set of symbols, arrows, and diagrams. What the most obvious difference in the modern art form in the ancient art form, is that there is no cutting or gluing involved. The modern form of origami uses strictly folds and patterns to create shapes. Yoshizawa, along with other origami masters, formed local and international organizations making the art form extremely well known.

II. Aspects regarding the Origami Instruction with a Gifted and Talented Population

Ancient origami designs inspire scientists and researchers to innovate and invent in order to solve authentic problems. The goal of origami is simple: transform a flat sheet of paper into a finished sculpture, without any cuts or glue. With these constraints and a limited set of folds, replication allows ease in solution finding. And this process for solution finding has manifested in a variety of authentic problem-solving ways. Citizen scientist teams compete on online gaming sites to try to unravel the mysteries of protein folding. NASA used folding techniques in the design of the James Webb Space Telescope, the Curiosity rover, and in space tethers. A new heart stent was inspired by the action of the origami balloon. The design of airbags is attributed to practitioners of origami. These limited examples express the need to incorporate origami understanding into the instruction of gifted and talented learners.

Noted researchers Piaget and Bruner justify hands-on learning for the development of gifted and talented students for its functional, inquiry-based merit. Piaget stressed the importance of learning by doing stating, “Involvement is the key to intellectual development,” and that development should include the “direct physical manipulation of objects” (Haury, 1994). Origami engages gifted and talented students in the practice of design cultivation and allows students to improvise their own challenges, their own solutions into origami construction. Bruner emphasizes inquiry-based learning as well: “the principal emphasis in education should be placed on skills - skills in handling, in seeing, and imaging, and in symbolic operations.” (Haury, 1994). This is where the significance in origami instruction of the gifted and talented student population is made obvious due to the mathematical, scientific, and engineering applications. Origami allows students to test engineering models of aerodynamics, velocity, motion, and volume. Spatial relationships of 3-dimensional objects may be kinesthetically investigated through origami applications.  And through origami construction, gifted and talented students may observe, measure, and graph data regarding the models.

In most classrooms, the needs of atypical students of all kinds are underserved. In “Programming opportunities for Students Gifted and Talented in the Visual Arts,” Clark and Zimmerman parallel this lack of service to need for “differentiated curricula and programming opportunities designed specifically to serve their unique characteristics.”  Yet, the Marland Report issued a multifaceted definition of gifted and talented students that recognized the visual and performing arts as aspects of giftedness (Marland, 1972). The lack of large scale, longitudinal studies and research, negatively affects the programming opportunities for students who are gifted and talented in the visual arts. While vested programming options including mixed ability grouping, grade skipping, and flexible promotions have continued to be incorporated for the gifted and talented students’ academic and intellectual benefit, visual arts courses exist our public school systems. However, the benefits of visual arts in the gifted and talented students are recognized. Artistically gifted and talented students increase their knowledge base as they broaden and deepen knowledge about art, sharpen art skills, and blend authentic learning with artistic expression.

Origami is appealing and highly motivating in its own right, yet, on the back of folding can be carried a wide range of associated learning. (Rootham-Smith, 2005). By incorporating the ancient arts of origami into instruction of the gifted and talented, student ability to develop problem-solving, analytical, and critical thinking skills through practical artistic representations is enhanced.  The use of the hands in this way is important in development of the brains' perceptions. Research suggests that the strong visual attraction in the connected polygons of origami may be due to underlying relationships that are found attractive in that they echo brain patterns (Rootham-Smith, 2005).  In origami, the hand movements of paper folding may enhance the connection between beauty and cognitive ability.

Folding is a simple, direct, but an immensely rich activity. Origami enhances science instruction by empowering gifted and talented students to be empowered in hands-on learning processes. Promotion of scientific inquiry through origami enhances critical thinking skills as well as develops discovery of scientific concepts in gifted and talented students. Origami forces student thinking by requiring interpretation of observed events, observation, and measure and graph data. Paper folding can be used as a technique to achieve vital academic objectives. Origami strengthens the significance of math in artistic expression providing a highly engaging and motivating environment within which children extend their geometric experience and the skill of spatial visualization. In math progression, geometry can be intimidating to students, yet, those same students applied geometric principles with origami to increase comprehension. Endless math concepts can be presented with Origami; areas of emphasis in mathematics instruction include geometry, symmetry, problem solving, and critical and analytical thinking. (Shalev, 2002). Origami demonstrates the fact that mathematics is a subject that can involve exploration. Gifted and talented students identify the revealed triangles, rectangles, and other geometric shapes implanted by origami. As origami activities implant in students’ conscious memory, they also develop the ability to think in the abstract regarding mathematics.

Origami challenges students to channel higher order thinking skills into a creative, visual medium. (Shalev, 2002). Friedrich Froebel (1782 – 1852), the German educator and founder of the kindergarten, who dedicated most of his life to the exploration of the learning process of young children, realized that a game for children is an educational tool of a great value. Origami in that sense has the characteristics of a game. Origami can be evaluated as a method of “active research”: there is a gradual progression, a sequential order, research into new relationships of folds, and creative possibilities, which encourage the advancement of new ideas. Paper folding combines the advantages of being instructive and attractive. It appeals to the creative, inventive, and constructive abilities of children and is an enjoyable activity that follows certain rules, it involves emotions, and it excites, entertains, and at the same time teaches through doing. (Shalev, 2005).

III. Summary

Origami benefits the world around us with its inventive and innovative nature. Gifted and talented students can connect the fun of origami and enhance science, mathematical, and engineering applications. Research provides evidence that the learning of various skills, science content, and mathematics increases as gifted and talented students participate in tactile programs. As well, origami can cooperative learning, foster cooperation, patience, and socialization in the gifted and talented student. Aligning origami to mathematics, specifically geometry, and studying how the folds of origami can positively impact the way researchers understand the folds of DNA, both have the potential of creating some profound impacts on the world. The potential influences origami has on the human race are inconceivable and in all likelihood were unimaginable to Akisato Rito, the first publisher of paper folding instructions.

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Origami Locomotion: A Medium for Powerful S.T.E.A.M.

Origami expresses power in both its artistic and application designs. UNC Professor Jack Snoeyink class is one example of this power. His course, “Folding: from paper to proteins,” examined shape and structure, explored through origami, robotics, and molecular biology. In his class, students considered questions about folding shapes and structures including gene design. For our unit, origami conveys power through the following principles:

The power to integrate the ancient art of origami into contemporary cultural relevancy. Origami is timeless – origami is currently practiced in Japan by the young and old. Yet, origami techniques are being employed in technologies ranging from space telescopes to car airbags. The [James Webb Space Telescope](https://sn2prd0102.outlook.com/owa/redir.aspx?C=Hap1JztxsE-zas3yLawA4_aD82Hxqc8I4Za8qy1sJ6BNvDGwj3SAAelsnalJaJneqHicGAuHF5I.&URL=http%3a%2f%2fwww.jwst.nasa.gov%2findex.html), the predecessor to the Hubble Telescope, to be launched in 2013, for example does have a mirror that folds up origami-style to be put into a rocket. This is referred to as optigami, and could only be achieved by the power origami enables.

The power to solve authentic problems. Today there are hundreds of origami applications being discovered, from helping to build self-assembling robots to providing clues as to how proteins fold into precise three dimensional shapes in the human body. This ability to solve real-world problems enables origami with the power to solve medical problems and influence the medical industry. Additionally, origami cultivates the ability to make model representations of improved architectural structures through design. American artist and architect, Richard Buckminster Fuller was considered a visionary who excelled in architectural design and inventions. On principles of origami, he designed the geodesic dome structure, which is known for its self-supporting nature. It is the only man-made structure which gets proportionally stronger as it grows in size.

The power to challenge students to channel higher-level thinking skills into a creative visual medium. One of the pioneers of modern math-based origami is [Robert J. Lang](https://sn2prd0102.outlook.com/owa/redir.aspx?C=Hap1JztxsE-zas3yLawA4_aD82Hxqc8I4Za8qy1sJ6BNvDGwj3SAAelsnalJaJneqHicGAuHF5I.&URL=http%3a%2f%2fwww.langorigami.com%2f), an American mathematician and origami artist. He created a computer program, TreeMaker, to design origami models.  Like, Lang, students may create their own design models as they synthesize their learning with higher-level thinking applications.

The power to strengthen the significance of math in artistic expression. Origami is a simple and effective way of teaching students about angles, lines and shapes. Origami can be used to explain many mathematical concepts in fields such as geometry, calculus, abstract algebra and others. Euclidian geometry can be solved through systematic approaches and essentially when students engage in the creation of origami sculptures. They are practicing specific and precise mathematical motions in their creative process. Origami enables the abstract to become concrete. Such is the case when considering origami having the power to solve mechanical engineering dilemmas. The kinesthetic manipulation of origami entices the student to solve problems seen in the world surrounding them.

Kinesthetic Kindling: Origami as a Catalyst for Digital Literacy

When considering the NETS-S strands (2007) established to enhance effective student use of technology, those stand being Creativity and Innovation; Communication and Collaboration; Research and Information Fluency; Critical Thinking, Problem Solving, and Decision Making; Digital Citizenship; and Technology Operations and Concepts, the implication is that technology tools can be resources for valid displays of creativity, higher level thinking skills, and digital literacy, in addition to a means to access content. In the vastness of the Internet, it is imperative that web-based searches be connected to curriculum; but, of equal importance is the credibility of the website itself. Technology and technology-based applications within the classroom need to be centered on building content awareness and furthering subject understanding.

Yet, our purpose in the design of this unit is to amplify the academically-gifted learners’ potential; to that end, these learners need to consider themselves as a participant in a global community of effective communicators. Academically gifted students must be well-versed in several collaborative technologies to accumulate essential skills (many emerging or not yet developed) needed in our global systems. To effectively implement technology during the course of our camp presentation, our utilization of technology must remain flexible to accommodate for new technologies, as well adaptive to the drive and creativity of student users. The best teaching plans are well-planned while flexible enough to allow for change. That being said, there are several applications of technology that we will incorporate into our unit as to provide delivery for student creativity.

One such platform we plan to incorporate into our unit are video clips.  Video enables the educators to reach children with a variety of learning styles, especially visual learners. By using video resources, educators may provide a common experience for student discourse and entice students into problem-solving and investigative activities. However, video clips are just that - no need to show a long clip to draw abstract conversation. Additionally, video clips, like content from a website, can enhance any part of lessons when used in a purposeful way.

Our aim in this unit of study - origami and its current relevance to mathematics, science, and engineering principles - is to illustrate complex, abstract concepts through animated, 3-D images. One such source of video clips will be Ted.com; this site was selected because of its consistent commitment to provide an ever-evolving medium through which to convey world-changing ideas. Our aim is to use TED.com to spark student interest initially as an introduction and with purpose and alacrity throughout the unit.

As Ted.com is ever-evolving, we additionally seek video lessons from TED-Ed to scaffold instruction. Education-based videos created by fellow educators would provide the hook for sparking the curiosity of our camp. Potentially, using this platform we may create our own customized lessons to support the rapid, yet purposeful delivery of our content and make share these lessons created using this platform with our camp class, as well as the greater TED-Ed community. In this lesson creation supported by the TED-Ed platform, another useful technology-based application for use as we cultivate our lesson delivery is the instructional video repository provided by the Khan Academy. This organization was created for the purpose of providing high-quality Internet-based tutorials and its freedom represents the best aspects technology provides in enhancing teaching instruction.

We additionally plan to harness the power of social medium as we incorporate technology tools like blogs or Edmodo into our curriculum. The following statements from Edmoto (2013) cite the rationale for using social-media in curriculum development: provides a platform for developing a sense of community among students; students can develop different learning styles; and, it fosters the use of 21st Century skills like communication, collaboration, critical thinking, and creativity. Of additional benefit is the factor that Pitt County students are familiar with Edmodo for conveying and responding to ideas. This attribute allows we as educators to utilize a platform students are familiar with, although not weary of using, thereby not detracting from the time constants of limited instructional time.  Our use of a platform such as a blog or Edmodo is that it can provide we as educators with the opportunity to make better use of time "in" the classroom by taking better advantage of time "outside" the classroom - i.e. "flipping" our temporary classroom. We may provide direct instruction via media platform as "homework" followed by students applying what they learned from the video-based instruction during our next class meeting. This “flipping” of the classroom may also be delivered through the flipping feature on TED-Ed.

Edmodo, or a similar platform that encourages communication such as a blog, provides a medium for active engagement to occur both within the classroom environment and beyond the classroom environment. Blogs, like traditional journaling, inspire creativity, writing, yet incline collaboration skills from peers, regardless of the subject matter. Its power lies in its ability to be engaging. The basic website creation platform, Weebly. com, has a blogging feature that might be a resource for communication to a wider audience; while Edmodo is a district utilized platform, for the purpose of this camp, and to extend the purpose of the lessons beyond the class environment, creating a website from Weebly. com, would provide a universally accessible forum with an educator-moderated blog feature.

Harnessing the power of technology to enhance both content and student creativity allows student engagement through various tools showcasing multiple learning styles. Many tools promote the student to be both actively engaged and emotionally engaged in his or her class, allowing the individual to work collectively with others to think, discuss, or create together. Via such collaborative tools, educators may serve as more of a facilitative and reflective role. This utilization,  in turn, is a best practice executed as students are the digital natives, welcoming and receptive to new technologies. (Housand) Through 21st century students, we must as educators channel the potential power these technology tools can amplify within learners.

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CONTENT OUTLINE

I. Real World Application of design principles of origami

   A. Perceptions of origami.

1. Origami is a means to communicate innovative ideas.
2. Origami has been manipulated and used by diverse cultures.
3. Origami art form can solve authentic mathematical problems.

   B. The ancient perception of origami as an art form.

1. The endless structures that origami can make.

     2. Traditional origami- where one piece of paper is folded using not cuts or glue to create an object.

           a. Folding an origami box.

  D. The modern perception of origami as an art form and its use to solve authentic problems.

1. Excerpts of Robert Lang’s video on the uses of origami.
2. The real problems origami can solve, such as the folding of airbags.
3. The Airbag

        a. Factors may include modern car designs, how car seatbelts were originally developed and why included in cars, safety aspects

        b. Students will build their own model airbag. The students will use the principles of origami, discussed on day one to create their own airbag

    E. Authentic problem-solving, use the problems from the origami box to develop future solutions

1. Both replication and construction impact design in origami

a. Benefits of origami are much more than a visual stimulant.

1. Origami allows for flexible design

a. Differing design principles have the potential to solve different problems.

1. Origami design principles have not fully been explored and have the possibility of being explored even more.

a. Problems students see and identify

* Students will create an origami solution to their self-selected real world problem or select from one of the following activities: science: DNA model;  architecture: paper city; space exploration' solar ray; math designs

II. Modular Origami/ Buckminster

   A. Modular origami versus the traditional thought of origami.

1. Modular origami- where two or more sheets are folded together to create geometric objects.

           a. Fold modular origami

   B. Introduction of geodesic dome.

        1. The geodesic dome and the founder.

        2. The geodesic dome as it relates to origami

  B. Buckey’s discovery

           1. Geodesic domes represents nature’s design principles, much like origami symbolizes aspects of nature.

        2. Quotes from Fuller

                a. “I’m not trying to imitate nature, I’m trying to find the pencil she’s using”

            b. “A problem looking for a solution”

                      i. Emphasis of these quotes to synthesize those authentic problems can be solved through the use of origami.

  C. Synergy.

          1. Buckminster Fuller invented term

            a. Its relationship to power

            b. Its expression of power

   D. How to create a geodesic dome using paper

1. Impact similar to Buckminster
2. Simplistic origami designs are the foundation for complex structures
3. Origami can be replicated to make and prove any given geometric and architectural problem.

   E. 2013 Buckminster Fuller Challenge Call for Proposals

1.Buckminster Fuller Institute awards

LESSON #1

*From 1000 Paper Cranes to Stellar Scopes*

|  |  |
| --- | --- |
| I. DEFINE OBJECTIVES AND CONTENT |  |
| LESSON OBJECTIVE | Students will apply a learned understanding of the ancient art of origami to express how its power is conveyed in the creation of origami designs. |
| POINT TO PONDER | “Origami is a metamorphic art form, you got that piece of paper, you don’t add to it you don’t take away from it , you change it”- Michael Lafosse |
| ESSENTIAL QUESTION | How can origami be used to solve authentic problems? |
| CONTENT  Outline the content you will teach in this lesson. | I. Real World Application of design principles of origami     A. Perceptions of origami.  1. The ancient perception of origami as an art form.  2. The modern perception of origami as an art form and its use to solve authentic problems.    B. Excerpts of Robert Lang’s video on the uses of origami.          1. The endless structures that origami can make.          2. The real problems origami can solve, such as the space telescope, cellular design |

|  |  |
| --- | --- |
| II. PLANNING: KNOW / UNDERSTAND / DO |  |
| What 3 items are worth knowing? | After the lesson,   * Students will KNOW that origami is a means to communicate innovative ideas. * Students will KNOW that origami has been manipulated and used by diverse cultures. * Students will KNOW that the origami art form can solve authentic mathematical problems. |
| What are the enduring understandings that students should take away from the lesson? | After the lesson,   * Students will UNDERSTAND the ancient origins of origami. * Students will UNDERSTAND multiple applications of origami. * Students will UNDERSTAND the power origami  holds to solve problems. |
| What 3 items are important for students to be able to DO? | After the lesson,   * Students should be able to create at least two origami designs, including  “problem” origami box and origami post-it design. * Students should be able to apply principles of origami to real world problems. * Students should be able to brainstorm problems origami can solve. |
| III. PLANNING |  |
| HOOK  Describe how you will grab students’ attention at the beginning of the lesson. Be CREATIVE. | TIME:10 minutes Show 25 Amazing Origami Artworks with class to illustrate creative origami designsDiscuss with class their prior knowledge of origami (Guiding question: what do you know about origami?)Teachers will chart of initial concepts of origami  * Students will create a shape using origami paper. * Students will discuss strengths and weaknesses of origami design principles as based on this introductory activity |
| INSTRUCTION  Explain Step-by-step what you will do in this lesson. Include ALL support and teaching materials with your unit. | TIME: 15 minutes.   * The students will watch pieces of the Robert Lang video.   Video guiding questions:  Students will watch will be the introduction of the art form itself, the authentic problems it has solved, and the multiple geometric shapes the paper is able to make.   * Students will discuss applications of origami as they connect to video and compare and contrast prior knowledge utilizing the chart of initial concepts of origami. (Guiding questions: What do you know about origami? Based on your viewing of the video, what do you now know about origami?) * Discuss with students design properties of origami:   2-colorability  Mountain-valley folds must be +/- 2  Angles around a vertex must be a straight line  No self-intersection at overlaps |
| ASSESSMENT  (Performance Task) What will the students DO to demonstrate that they have mastered the content? Be specific and include actual assessment with unit materials. | TIME: 45 minutes  Students will each create an individual origami “problem” box measuring 6”x6” out of origami paper that they will keep with them throughout the week.  Students will fold many designs including at least these four:  a fox family  windmills  beads  star   1. Student will have both print and video instructions regarding how to fold the origami box 2. They will identify possible problems that can be solved using origami and fold their paper with problems written on them into a form of origami. The problems will be kept in the box for the remainder of the week and problems will be added as the week progresses. 3. Students will share their problems that could be solved using origami with the class. 4. Teachers will introduce The Foldable Mathlete website, discuss purpose of website (i.e. sharing new understanding of origami based on information gained at camp, providing a forum for images and ideas regarding origami to be shared) 5. Teachers will guide students through creation of the website pages (essentially, the website will house each day’s essential question and per day images and blog postings will be updated.) 6. Students will modify the design of the unit website to document their reactions and images to today’s lesson regarding origami principles. 7. Students will post to the website blog the possible problems they individually established that can be solved using origami. (Guided response question: How can origami be used to solve authentic problems?) |

DOES THE ASSESSMENT ALLOW YOU TO DETERMINE WHETHER OR NOT THE STUDENTS HAVE MET YOUR STATED LESSON OBJECTIVE?   ***YES*** OR NO

ASSESSMENT AND INSTRUCTIONAL MATERIALS

Primary Teacher-created Material:

Classroom website with blog feature: [http://thefoldablemathlete.weebly.com](http://thefoldablemathlete.weebly.com/)

1. Origami paper/ regular paper

2. Laptops for website

3. Origami Post-it Action cards: cards provided by Marbles Kids Museum: <http://www.marbleskidsmuseum.org/action>

4. How to fold an origami box: <http://www.origami-instructions.com/origami-box.html> and video <http://www.origami-instructions.com/origami-box-video.html>

5. Origami Sticky notes: <http://www.thinkgeek.com/product/b21b/>

6. Robert Lang video: <http://www.ted.com/talks/robert_lang_folds_way_new_origami.html>

7. 25 Amazing Origami Artworks <http://list25.com/25-amazing-origami-artworks/>

8.The Usborne Book of Origami for origami design templets

Day 1 Guiding Video Clip Questions

<http://ed.ted.com/lessons/robert-lang-folds-way-new-origami#dig>

1. **What makes an object origami?**

A It’s made out of one sheet of paper

B The paper is always folded diagonally

C The paper must be folded, never cut

D When finished, it must fit in the palm of your hand

E B and C

F A and C

1. **Robert Lang observes about origami, “You would think something that’s been around that long—so restrictive, folding only—everything that could be done has been done a long time ago.” Yet there’s been an explosion of interest and new creativity in origami in the past several decades. According to Lang, what are the reasons for this rebirth?**
2. **Lang explains that all origami follows four simple laws—yet these give rise to an astonishing array of designs. Can you think of another example in science or math where a fairly simple system or set of rules can create amazing diversity?**
3. **What’s remarkable about Robert Lang’s origami rattlesnake?**

A It sports a thousand scales

B It’s eating an origami rabbit

C It contains 160 folds, yet it’s no bigger than a thumb

D It actually rattles!

1. **Origami is a wonderful example of how math and art may intersect. What are other art forms that embody mathematical concepts, in particular geometry?**

Day 1 Directions for Making an Origami Box

<http://www.origamiway.com/origami-box-2.shtml>



Step 1: Start with a square piece of [origami paper](http://www.origamiway.com/origami-paper.shtml). If you only have regular 8.5x11 paper, follow these instructions to [make a square sheet](http://www.origamiway.com/make-origami-paper.shtml).

Step 2: Fold the paper in half from top edge to bottom edge, and then unfold.

Step 3: Fold in half again from left to right, and then unfold.

Step 4: Fold all four corners to the center.

Step 5: Rotate the paper so it becomes a square.

Step 6: Fold the top and bottom edge to the center, and then unfold.

Step 7: Unfold the top and bottom triangles.

Step 8: Fold the left and right edges to the center.

Step 9: Lift the top part to make it stand up at the crease like in the picture.

Step 10: While holding the top part with one hand, open the left side with the other hand to form one corner of the box.

Step 11: Do the same to the right side.

Step 12: Form the two lower corners of the box also.

Step 13: Fold the top flap down into the box.

Step 14: Fold the lower flap down into the box. That's it!

LESSON #2

*Fullerenes - The Biggest Guy on the Block*

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| --- | --- |
| I. DEFINE OBJECTIVES AND CONTENT |  |
| LESSON OBJECTIVE | Students will understand how geodesic domes are built through the use of origami principles and synthesize the strength/ power achieved through the use of this construction technique by creating large (4’x4’) geodesic domes. |
| POINT TO PONDER | “I’m not trying to imitate nature, I’m trying to find the pencil she’s using”-Buckminster Fuller |
| ESSENTIAL QUESTION | How do origami principles strengthen the principles of design? |
| CONTENT  Outline the content you will teach in this lesson. | II. Modular Origami/ Buckminster    A. Introduction of geodesic dome.          1. Students will view video on the geodesic dome and the founder.          2. Students will discuss how the geodesic dome directly relates to origami.    B. Buckey’s discovery             1. Students will observe and analyze how geodesic domes represent nature’s design principles, much like origami symbolizes aspects of nature.          1. “I’m not trying to imitate nature, I’m trying to find the pencil she’s using” Analysis          2. “A problem looking for a solution”  Analysis              By placing emphasis on these quotes, our students will synthesize that authentic problems can be solved through the use of origami.    C. Synergy  1. Buckminster invented the word; discuss its relationship to power, how it expresses power     D. How to create a geodesic dome using paper.          1. The video will be used as instruction. The entire video will not be used, just the pieces needs to instruct.    E. 2013 Buckminster Fuller Challenge Call for Proposals        1. Buckminster Fuller Institute        2. Authentic problem-solving, use the problems from the origami box to develop future solutions. |
| II. PLANNING: KNOW / UNDERSTAND / DO |  |
| What 3 items are worth knowing? | After the lesson,   * Students will KNOW that geodesic domes are resilient man-made structures. * Students will KNOW that geodesic domes can be built using origami principles * Students will KNOW that Buckminster had an impact on design principles |
| What are the enduring understandings that students should take away from the lesson? | After the lesson,   * Students will UNDERSTAND that students can have an impact similar to Buckminster regarding practical, inexpensive shelter and transportation designs and inventions * Students will UNDERSTAND “ the combination of simple folds and twists can result in very complex structures,” that combine “meditation, obsession and sense of symmetry” (Peter Keller) * Students will UNDERSTAND that origami can be replicated to make and prove any given geometric and architectural problem. |
| What 3 items are important for students to be able to DO? | After the lesson,   * Students should be able to build geodesic domes using mixed media. * Students should be able to analyze which dome built would have the most reliable and strong structure. * Students should be able to build their own geodesic dome. |

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| III. PLANNING |  |
| HOOK  Describe how you will grab students’ attention at the beginning of the lesson. Be CREATIVE. | TIME: 10 minutes.   * Students will review Bubble Domes clip and record observations. (Guiding questions: What do you notice about the structure of bubble domes? How can the strength of bubble domes be measured? How can the strength of bubble domes be improved?) * Students will recreate bubble domes as they blow bubbles onto cardboard. * Students will analyze dome structure of bubbles and observe strength dome shapes create. * Students will compare and contrast natural bubble dome design and man-made dome construction |
| INSTRUCTION  Explain Step-by-step what you will do in this lesson. Include ALL support and teaching materials with your unit. | TIME: 15 minutes.   * Students will discuss how in the 1990s, origami artists discovered they could make a seemingly infinite array of complicated figures by starting with a very specific sequence of five folds * Students will watch clips of a video on Buckminster Fuller in order to understand his background information. * Students will discuss quotes from Buckminster Fuller to consider implications and applications of origami/ geodesic dome structure   Video quotes to analyze:   1. What are three factors Buckminster Fuller researched regarding housing in the early 20th century? 2. How did Buckminster Fuller applying modern technological know-how to shelter construction? 3. How did Buckminster Fuller making shelter more comfortable and efficient. 4. How did R. Buckminster Fuller strive to make shelter more economically available to a greater number of people?  * Students will watch a short video to understand the construction of a geodesic dome/ bucky ball and will read through instructions on how to create one. A useful site to see how to create Buckyballs without glue or tape will be provided: <http://www.wonderville.ca/asset/buckyball-origami> |
| ASSESSMENT  (Performance Task) What will the students DO to demonstrate that they have mastered the content? Be specific and include actual assessment with unit materials. | TIME: 45 minutes   1. Students will design their own buckyballs and geodesic domes. These will be large 4’x4’ cardboard domes. 2. Student will write/ type their designs prior to construction 3. To scaffold design and execution of geodesic domes, video guides will be available. 4. Students will use their design instructions to construct their own 4’x4’ geodesic dome. 5. While constructing geodesic domes, students will record challenges and design modifications. 6. After students have completed their design, teachers and students will have a discussion of which design and execution of design is the strongest and how the design relates to origami principles. 7. Students will respond to their reaction of the day using the classroom website’s blog feature. (Guiding question: How do origami principles strengthen the principles of design?) 8. Introduce the Buckminster Fuller challenge proposal as a task for students to consider (ponder, but not execute) |

DOES THE ASSESSMENT ALLOW YOU TO DETERMINE WHETHER OR NOT THE STUDENTS HAVE MET YOUR STATED LESSON OBJECTIVE?   ***YES*** OR NO

ASSESSMENT AND INSTRUCTIONAL MATERIALS

Primary Teacher-created Material:

Classroom website with blog feature: [http://thefoldablemathlete.weebly.com](http://thefoldablemathlete.weebly.com/)

1. Video clips on the geodesic dome and the founder.

<http://www.youtube.com/watch?v=d0_DKeFfObI&safety_mode=true&persist_safety_mode=1&safe=active>

2. How the geodesic dome directly relates to origami.

<http://bfi.org/about-bucky/buckys-big-ideas/geodesic-domes>

3. How geodesic domes/Bucky balls are constructed: <http://www.youtube.com/watch?v=vv01yWHo_1o&safety_mode=true&persist_safety_mode=1&safe=active>

<http://invention.smithsonian.org/centerpieces/ilives/kroto/buckyball.pdf>

4. Cardboard for construction of bucky balls/ geodesic domes

5. Bubble wands, bubbles

6.  Clips from the audio of how Buckminster Fuller’s discovery relates to nanotechnology, other modern concepts  <http://www.hark.com/clips/pvkjhgmmdv-happy-birthday-buckyballs>

7. Laptops for website

8. Bubble dome website for hook clips: <http://www.youtube.com/watch?v=ajVnJ9yphTI&safety_mode=true&persist_safety_mode=1&safe=active>

9. Directions for making pieces of Buckyballs <http://www.wonderville.ca/asset/buckyball-origami> or <http://www.nisenet.org/sites/default/files/catalog/uploads/9728/buckyballorigamiv02.pdf>



LESSON #3

*Small Size Save Lives*

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| I. DEFINE OBJECTIVES AND CONTENT | Introduce one general problem and model solutions through problem-solution method |
| LESSON OBJECTIVE | * Students will apply folding principles of origami to solve one problem (design properties of origami: 2-colorability, mountain-valley folds must be +/- 2, Angles around a vertex must be a straight line, No self-intersection at overlaps) * Students will develop multiple solutions to one problem through discussion and then practice using the problem-solution method. |
| POINT TO PONDER | “Camping enthusiasts and aspiring modern sculptors take heed: researchers have achieved a breakthrough in understanding and controlling over curvature, which is found in such disparate settings as pop-up tents, DNA plasmids and curved origami.” James Joyner |
| ESSENTIAL QUESTION | How can the ancient art of origami be used to solve modern quandaries involving foldability? |
| CONTENT  Outline the content you will teach in this lesson. | I. The Air Bag -        A. Why is designing an air bag challenging  1.a simulation of an inflated airbag needs to start with a simulation of a folded-up airbag  2.first treat it as a rigid object, then find creases that flatten it, then fold it up into a small packet  B. How can different designs be developed  1. one needs to flatten a set of polygons so that their edges remain aligned to one another  2. polygons are all part of a single square of paper, but they could as easily be the polyhedral facets of an inflated airbag  3. “universal molecule” - directly applicable to the airbag problem, providing the solution for how to flatten a large class of shapes in simulation.  C. Relationship between ancient art of origami and practical application to modern dilemas  1. review of (design properties of origami: 2-colorability, mountain-valley folds must be +/- 2, Angles around a vertex must be a straight line, No self-intersection at overlaps) |
| II. PLANNING: KNOW / UNDERSTAND / DO |  |
| What 3 items are worth knowing? | After the lesson,   * Students will KNOW that origami principles apply to innovations providing folding techniques employed by companies/ inventors worldwide. * Students will KNOW that replicating folds in origami can influence design. * Students will KNOW that through manipulation of origami construction applications to space travel can be adjusted and manipulated for size. |
| What are the enduring understandings that students should take away from the lesson? | After the lesson,   * Students will UNDERSTAND that both replication and construction impact design in origami. * Students will UNDERSTAND that origami allows for flexible design. * Students will UNDERSTAND that all design principles have not fully been explored and have the possibility of being explored even more. |
| What 3 items are important for students to be able to DO? | After the lesson,   * Students should be able to create their own design application. * Students should be able to build model air bags by manipulating the size and dimensions. * Students should be able to replicate airbag designs. |

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| III. PLANNING |  |
| HOOK  Describe how you will grab students’ attention at the beginning of the lesson. Be CREATIVE. | TIME: 15 minutes   * Video of airbag construction will be playing in the background silently. * As the video is playing, students will hypothesize how to build an air bag, recording hypothesis on paper. |
| INSTRUCTION  Explain Step-by-step what you will do in this lesson. Include ALL support and teaching materials with your unit. | TIME: 15 minutes   * Discuss with students the need to design air bags. Factors may include modern car designs, how car seatbelts were originally developed and why included in cars, safety aspects, etc. There will be a verbal discussion with the students and a classroom Venn diagram completed discussing similarities and differences between seatbelts and airbags. * Teachers will have cues to give students but ultimately it will be the students who come up with answer. (Examples of similarities and differences, How they are constructed, what their purposes are) * The purpose of each type of design discussed is a key piece so that students are familiar with the potential benefits of origami designs. * Discuss Lang’s many applications for origami, focusing on airbags that fold down inside the steering wheel * (Alternatively, Skype with packaging/folding design engineer to discuss elements of folding a structure into a defined space   Questions to ask include:   * + How much is the folding carton industry worth worldwide?   + What materials do you work with?   + How do factors such as rigidity and weight play a role in the folding carton industry?   + What are some methods or technologies the folding carton industry integrates into packaging?   + How does environmental sustainability play a role in your design and production process? |
| ASSESSMENT  (Performance Task) What will the students DO to demonstrate that they have mastered the content? Be specific and include actual assessment with unit materials. | TIME: 40 minutes   * Guide the students to evaluate why origami is a useful practice when considering ramifications of technology innovations. * Students will build their own model airbag. The students will use the principles of origami, discussed on day one to create their own airbag (fold lines, size... etc). * Students will review the dimensions of each piece of origami and create their own. * Students will design a new airbag structure. * Students will write their reaction to the day’s lesson on the blog. (Guiding question: How can origami be used to solve quandaries when size is a factor?) |

DOES THE ASSESSMENT ALLOW YOU TO DETERMINE WHETHER OR NOT THE STUDENTS HAVE MET YOUR STATED LESSON OBJECTIVE?  ***YES*** OR NO

ASSESSMENT AND INSTRUCTIONAL MATERIALS

Primary Teacher-created Material:

Classroom website with blog feature: [http://thefoldablemathlete.weebly.com](http://thefoldablemathlete.weebly.com/)

1. Airbag video for rationale:  <http://www.youtube.com/watch?v=YHJOXhABpH4&safety_mode=true&persist_safety_mode=1&safe=active>

2. Airbag video for background: <http://www.youtube.com/watch?v=9h-b2lKOVmE>

3. Airbag rationale: <http://www.youtube.com/watch?v=vK0kCFvkaCA&safety_mode=true&persist_safety_mode=1&safe=active>

2. Airbag information from: <http://www.langorigami.com/science/technology/airbag/airbag.php>

3. Origami/ Construction paper for design execution

4. Designs of seat belts: <http://en.wikipedia.org/wiki/Seat_belt>

5. Crash tests: <http://www.youtube.com/watch?v=d7iYZPp2zYY&safety_mode=true&persist_safety_mode=1&safe=active>

LESSON #4

*To Boldly Fold where no one has Folded Before*

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| I. DEFINE OBJECTIVES AND CONTENT |  |
| LESSON OBJECTIVE | To solve student selected problems utilizing the visual and design power of origami to construct a solution. |
| POINT TO PONDER | Origami empowers the artist with design application to become a scientist and vice-versa. |
| ESSENTIAL QUESTION | How does the application of your origami design solve a real world problem? |
| CONTENT  Outline the content you will teach in this lesson. | * Teachers will assist students by modeling the scientific process as it applies to student identified real world problems. * Teachers will introduce the scientific method as it relates to origami: (The scientific method is the process by which scientists, collectively and over time, endeavor to construct an accurate (that is, reliable, consistent and non-arbitrary) representation of the world.) * Teachers will link the practice of origami to the scientific method through emphasizing why the number of folds is consistently important to design and replication   (Guiding questions:  Why is replication critical to origami design?  Why is the number of folds and sequence of folds essential to origami structural design?  How is consistency between the number and sequence of folds similar to the scientific process?)   * Teachers will outline the steps of the scientific method:   Step 1: Observation and description of a phenomenon or group of phenomena. Discuss through class discussion real world problems that students think could be solved through origami. Teachers will refer to instruction from previous days. (Discuss Lang’s many applications for origami, including: a heart stent that folds down while it moves through the blood vessels; b. a telescope lens that packs up to fit into a rocket payload area; and c. airbags that fold down inside the steering wheel**)**  Step 2: Formulation of a hypothesis to explain the phenomena. Students will guidance of teachers will narrow down a real world problem that origami could be used to solve. Students will pose a hypothesis prior to construction of real world problem he or she selects. These problems determined by teachers will most likely focus on scientific, technological, engineering, and/or mathematical concepts.  Step 3: Use of the hypothesis to predict the existence of other phenomena, or to predict quantitatively the results of new observations. Students will design original origami produce based on hypothesis. Students will record steps of original origami design including fold number and sequence. Teacher will facilitate learning by assisting and scaffolding learning when necessary.  Step 4: Performance of experimental tests of the predictions by several independent experimenters and properly performed experiments. Students will complete his or her design to display as part of a class gallery walk. Students will share instruction methodology and steps in completion of their original origami design on class website. Students will share instructions and design with visiting parents during the concluding activities of camp, as well as their website content.  (The “Introduction of the Scientific Method steps were provided from: <http://teacher.nsrl.rochester.edu/phy_labs/appendixe/appendixe.html>) |
| II. PLANNING: KNOW / UNDERSTAND / DO |  |
| What 3 items are worth knowing? | After the lesson,   * Students will KNOW that origami has the potential to solve problems. * Students will KNOW that constraint differ when using origami. * Students will KNOW that proposed designs have validity. |
| What are the enduring understandings that students should take away from the lesson? | After the lesson,   * Students will UNDERSTAND that differing design principles have the potential to solve different problems. * Students will UNDERSTAND that problems they see and identify, they have the power to solve. * Students will UNDERSTAND that benefits of origami are much more than a visual stimulant. |
| What 3 items are important for students to be able to DO? | After the lesson,   * Students should be able to create a prototype solution for a problem identified. * Students should be able to apply ancient origami principles to modern design to ancient origami principles. * Students should be able to evaluate strengths of origami principles over other design principles. |

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| III. PLANNING |  |
| HOOK  Describe how you will grab students’ attention at the beginning of the lesson. Be CREATIVE. | TIME: 15 minutes   * Discuss Lang’s many applications for origami, including: a heart stent that folds down while it moves through the blood vessels; b. a telescope lens that packs up to fit into a rocket payload area; and c. (reference to day 3)airbags that fold down inside the steering wheel * Students will unpack their box of problems from their origami box. Created day one and added to each day, this box of problems will be assessed to see which problems could viably be solved using design principles of origami. * Boxes and problems will be mounted onto matte board using tacks. * Beside each problem, students will write why they think that a problem could or could not be authentically solved using origami. * The class will conduct of gallery walk of problems to see what classmates say about the role origami plays in finding solutions to problems. |
| INSTRUCTION  Explain Step-by-step what you will do in this lesson. Include ALL support and teaching materials with your unit. | TIME: 10 minutes   * Teachers will provide 3-5 problems to solve to supplement problems they might have selected on their own (to provide students the illusion of choice) * Students will share a problem they have chosen to solve with classmates and hypothesize in discussion how well their design will work. |
| ASSESSMENT  (Performance Task) What will the students DO to demonstrate that they have mastered the content? Be specific and include actual assessment with unit materials. | TIME: 45 minutes   * Students will create an origami solution to their self-selected real world problem or select from one of the following activities:   1. science: DNA model   2. architecture: paper city   3. space exploration: solar ray   4. math : foldable geometry   .   * Students will record on paper the necessity and merits of their design * Students will create the instruction and execute the structure. * Students will visually share design and structure with class. * Students will upload images and instructions to the website. * Students will attempt to have others replicate their design. * Students will write their reaction to the day’s lesson on the blog. (Guiding question: How does the application of your origami design solve a real world problem?) |

DOES THE ASSESSMENT ALLOW YOU TO DETERMINE WHETHER OR NOT THE STUDENTS HAVE MET YOUR STATED LESSON OBJECTIVE?   ***YES*** OR NO

ASSESSMENT AND INSTRUCTIONAL MATERIALS

Primary Teacher-created Material:

Classroom website with blog feature: [http://thefoldablemathlete.weebly.com](http://thefoldablemathlete.weebly.com/)

1. Origami box containing student self-selected authentic “problems”

2. Origami/ Construction paper for design execution

3. Laptops for website

4. DNA design model replication video: <http://www.youtube.com/watch?v=YIgQDPrc5Ak&list=FL8jLE6dJqhrZuczkr_4LvTg&index=36>

5. Additional DNA design model for replication; <http://www.youtube.com/watch?v=0jOapfqVZlo&list=FL8jLE6dJqhrZuczkr_4LvTg&index=37&safety_mode=true&persist_safety_mode=1&safe=active>

6. Paper city Architecture Model: <http://www.youtube.com/watch?v=rdk2D0LfjLw&safety_mode=true&persist_safety_mode=1&safe=active>

7. Space exploration Solar Ray: <http://www.youtube.com/watch?v=Y4fpU5W-3n8>

8. Mathematical Principle design; <http://www.youtube.com/watch?v=oUnNkHGXefA&safety_mode=true&persist_safety_mode=1&safe=active>

9. Lang video clips from TED talks: <http://www.ted.com/talks/robert_lang_folds_way_new_origami.html>

**Day 4: Solar Sails in Space Flight Templet**

<http://www.origami-resource-center.com/origami-science.html>



In March of 1995, Japanese scientists used origami concepts to pack and deploy a solar power array in the research vessel called Space Flight Unit (SFU). On Earth, the solar array was folded into a compact parallelogram, and then in space, it was expanded into a solar sail. The method of folding the solar panels is called "Miura-ori", in honor of Koryo Miura, a professor in Tokyo University, who developed the fold.

The Miura-ori (translation = Miura-fold) is famous in map folding. The Miura-ori allows a square piece of paper to be folded in such a way that it can be opened (in one motion) by pulling at two opposite corners. As well, a Miura-ori folded map is less likely to tear at the crease junctions. An easy to use road map - now that's origami science!



a [diagram](http://mars.wnec.edu/~thull/combgeom05/handout7.pdf) by Tom Hull