Cooperative Learning Lesson: Tetrahedral Kites

Cooperative Learning Lesson: Tetrahedral Kites

Step 1: SUBJECT MATTER CONTENT:

A. Learning Objective: Working in cooperative groups, the learners will develop their own tetrahedral kites and a table that summarizes their mathematical findings.
B. Purpose of the Lesson: Each student is responsible for their own tetrahedral kite and report of their findings. In groups, the learners can use each other for support in the construction and investigation as they develop patterns and rules. This lesson supports various learning styles, incorporates differentiation and technology, encourages exploration, and builds good social skills.
C. Learning Experiences that precede group work: Students will have finished a unit on Geometry and Measurement.
D. Duration: This lesson will take three class periods for construction and one class period for flying.

Step 2: GROUP COMPOSITION AND ROOM ARRANGEMENT:

A. Group Size: Four students.
B. Assignment Groups: Teacher selected based on achievement level and learning style. The learners have filled out a differentiation survey on how they learn (from Teach21) and will be grouped accordingly. Moreover, the achievement levels within groups are based on average and high level learners and average and low level learners to ensure the learners work together, the pace is comfortable for all members, and the achievement levels are similar.
C. Duration of Group: 4 Days.
D. Room Arrangement: The students are working in an open classroom with large tables. They have ample floor space and table room to spread out their materials during the construction. This setup allows learners to work together in open space with proper resources opposed to sitting side by side.

Step 3: POSITIVE INTERDEPENDENCE: Challenging tasks are selected and orchestrated so that students must rely on each other's thinking in positive ways

A. Resource Interdependence: Co Op Design. The group explores patterns and tries to identify rules as they investigate their kites. The group discussion benefits each members' understanding and they turn in a group write up along with the table of their findings. Then each group will share their learning experience and findings with the rest of the class.
   - ◊ Roles: The groups are given four roles, one for each, that ensure that the group is focused and learning together.
     - ◊ Facilitator-keeps the group on task and focused using time management skills
     - ◊ Leader/encourager-makes sure all voices are heard and that everyone is listening to one another. They ensure all ideas are out in the open and provide positive encouragement.
     - ◊ Recorder/elaborator- compiles the group's findings and conjectures and researches the validity of the claims discussed by the group.
     - ◊ Reflector/summarizer- Summarizes the findings and ensures that everyone understands before the group proceeds. Seeks clarification and attempts to connect ideas and build on concepts discussed.

◊ Aside from these roles, each group member is responsible for their own kite construction.

B. Accountability Interdependence: Aside from these roles, each group member is responsible for their own kite construction. To ensure each learner understands the patterns and rules, the teacher will ask questions throughout the construction and flying to assess their individual understanding.

Step 4: SUBJECT MATTER DIRECTIONS:
"Your group will work cooperatively to..."

A. Successfully Build Tetrahedral Kites
B. Identify Patterns and Rules for N-Celled Tetrahedral Kites
C. Summarize the Findings in the Table

Step 5: SOCIAL SKILL
Group participants are expected to reflect regularly on and evaluate behaviors that support or hinder their cooperation with each other. One way to do so is a group confidentiality form, shown below.

Sample Confidential Group Evaluation Form

Project Topic:____
Evaluator: ____ **Date:**____________
Directions:
Rate your contributions and those of each member of your group for work you completed together on the group project. This evaluation is confidential. For each group member: Write the person's name in the first row of the table below, one name per column. Use a rating scale from 0 to 4 for each category with the meaning:

0: unacceptable performance
1: adequate but irregular performance
2: acceptable but irregular or last minute performance
3: acceptable performance with minor follow-up required
4: consistently strong performance.

Write the **Rating** in the labeled column. *This is not a rank ordering.*

- Calculate **Rating** × **Weight** = Points. Enter this value in the **Points** column.
- Add the values in the Points column and write the total in the last row of the table.
- For your project grade, individual scores will be computed as a percentage of the total points earned. The percentage earned is the average of the ratings provided by group members.

Person Evaluated		**Yourself**							
Category	**Weight**	**Rating (0-4)**	**Points**	**Rating (0-4)**	**Points**	**Rating (0-4)**	**Points**	**Rating (0-4)**	**Points**
Written Communications	2								
Spoken Communications	2								
Organization and Planning	2								

Initiative and Dependability	2								
Interpersonal Relations	2								
Quality of Research Completed Together or Independently	5								
Ability to Analyze and Summarize Information	10								
TOTAL POINTS									
Describe your contribution to the work completed toward the project. Be specific. How thorough, thoughtful, and accurate were your contributions?									

Step 6: PROCESSING.

The learners can answer the "group process questions for discussion" individually and reflect as a group on how they could have been more effective as well as what they did well as a group.

1. Did your group achieve at least one solution to the problem or task?
2. Did everybody understand the solution?
3. Did people ask questions when they didn't understand?
4. Did people give clear explanations?
5. Did everyone have a chance to contribute ideas?
6. Did people listen to one another?
7. Did any one person take over the group?
8. Did the group really work together on the task?
9. Was there enough time for exploration?

(Davidson, 1990)

Tetrahedral Kites

Overview

Each student constructs a tetrahedron and describes the linear, area and volume using non traditional units of measure. Four tetrahedra are combined to form a similar tetrahedron whose linear dimensions are twice the original tetrahedron. The area and volume relationships between the first and second tetrahedra are explored, and generalizations for the relationships are developed.

Objectives

Students will:

- Briefly Review Kite History
- Construct a tetrahedral puzzle
- Construct a tetrahedron from straws, thread, and tissue paper
- Combine four tetrahedra to make a larger tetrahedron
- Calculate the surface area of 3-D shapes
- Discover the relationship between the linear, area, and volume measures of similar polyhedral
- Develop mathematical rules for an n-celled tetrahedral kite

Standards

NCTM Standards and Expectations: Geometry 6-8

1. Understand relationships among the angles, side lengths, perimeters, areas, and volumes of similar objects.
2. Use two-dimensional representations of three-dimensional objects to visualize and solve problems such as those involving surface area and volume.

Common Core Standard:

7.G. 6: Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms

Instructional Plan

In this lesson, students work together in groups to create tetrahedron models using straws, string, and tissue paper. The models are then combined to make larger tetrahedrons, and students compare the ratios of edge length, area, and volume of the models in an attempt to understand scaling factors.

To begin the lesson, organize your class into cooperative groups of four students. To create a bond among the students in each group, begin with the historical aspect and have them discuss what they find together. Give each group the activity sheet and have the team leader distribute the materials. Once everyone has their materials we will build the first tetrahedron together, we will call it tetrahedron 1. Then they will construct the remaining three in their groups and will use each other for support, we will call the final product with all four tetrahedral, tetrahedron 2.

Once the models are complete, students will compare the edge length, area, and volume of Tetrahedron 1 and Tetrahedron 2. Ask the questions in the *Questions for Students* section below. This discussion is the primary focus of the lesson, and students should be given ample time to discuss each question with the members of their group.

Questions for Students

1. Compare a face of Tetrahedron 1 with a face of Tetrahedron 2. Describe what you see.
    a. The face of Tetrahedon 1 is one equilateral triangle. The face of Tetrahedron 2 is made up of four equilateral triangles, each congruent to one face of Tetrahedron 1.
2. How do you know that the triangular face of Tetrahedron 1 similar to the triangular face of Tetrahedron 2?
    a. Each of the corresponding edge lengths is twice as long, and the corresponding angles are congruent.
3. What are the ratios of edge length and area from Tetrahedron 1 to Tetrahedron 2?
    a. Edge length, 1:2. Area, 1:4.
4. Based on your table, make a conjecture about the relationship between the edge length ratio and the area ratio of similar figures.
    a. The area ratio of similar figures is the square of the edge length ratio. Test this conjecture with other similar polygons.

Assessment Options

1. In whole-class discussions, ask students to describe the relationships they discovered in their table regarding similar figures and have them give examples to validate their claims. Encourage and validate a variety of appropriate responses.
2. Ask students to write an entry in their journals that includes the following pieces:
3. A summary of what they found regarding the relationships they discovered. Examples that support their summary.
4. Any tables, charts, or other tools they used to organize their information.

Extensions

1. Explore the relationships between the formulas for finding the volumes of prisms and pyramids.
2. Determine a ratio that describes the volume of Tetrahedron 1 and Tetrahedron What shape fills the open space?
3. Combine four copies of Tetrahedron 2 to make Tetrahedron 4, and then combine four copies of Tetrahedron 4 to make Tetrahedron 16. Use these models to explore the relationship between edge length ratios, area ratios, and volume ratios of similar figures with various scale factors. Can students explain the names given to each tetrahedron model?

Teacher Reflection

1. How did your lesson address auditory, tactile and visual learning styles?
2. Were concepts presented too abstractly? Too concretely? How would you change them?
3. What worked with classroom behavior management? What didn't work? How would you change what didn't work?
4. Did you challenge the achievers? How?
5. What content areas did you integrate within the lesson? Was this integration appropriate and successful?
6. How did your lesson address auditory, tactile and visual learning styles?

BELL'S AEROPLANE FLIES.
New York Times (1857-1922); Dec 7, 1907;
ProQuest Historical Newspapers The New York Times (1851 - 2008)
pg. 1

BELL'S AEROPLANE FLIES.

Tetrahedral Kite Carries a Man High Above a Lake in First Test.

BADDECK, C. B., Dec. 6.—The tetrahedral kite Cygnet, invented by Prof. Alexander Graham Bell, made a successful ascent to-day above the waters of the Brae d'Or Lakes, where Prof. Bell's Summer home and experimental laboratory are located. Carrying Lieut. Thomas E. Selfridge of the United States Army, it soared aloft with remarkable ease and maintained its poise without accident, while it was towed along by a small steam launch.

Thus far the Cygnet has no motor for self-propulsion, although a place was provided when it was built. Prof. Bell desired to make practical tests of buoyancy and balance, and the ascent to-day was one of these.

Mounted on the floating platform with which it was launched some weeks ago the big kite was taken in tow by the launch. As the speed of the launch increased the kite gradually left the platform, and soon, amid the cheers of the small group of onlookers, soared to a considerable height. Lieut. Selfridge was able to manipulate the aeroplane at will and to preserve its poise with apparent ease.

PREPARING FOR FLIGHT THROUGH THE AIR
New York Times (1857-1922); May 29, 1904;
ProQuest Historical Newspapers The New York Times (1851 - 2008)
pg. SM1

PREPARING FOR FLIGHT THROUGH THE AIR

Professor Bell Ready to Resume Experiments in Cape Breton —His Wonderful Tetrahedral Kites.

WASHINGTON, May 28.—The study of flight in the air has a peculiar charm to one who engages in it. The problem, so simple that the smallest fledgling may in a dozen efforts master it, leads to a dream of the conquest of space and time, perhaps the greatest of which the human mind has ever taken thought. For the past five years Dr. Alexander Graham Bell, the inventor of the telephone, has been experimenting at his Summer home near the little village of Baddeck, Nova Scotia, with tetrahedral kites as the means of devising an aerial locomotive.

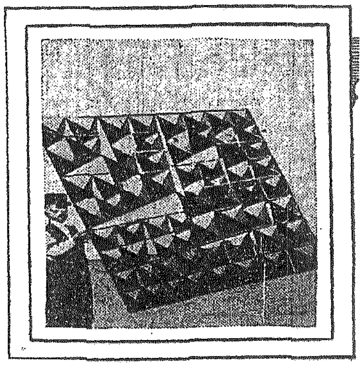
The region is one most favorable for the study of aerial flight and experiments with different devices to accomplish it. Baddeck, made famous twenty-five years ago in Charles Dudley Warner's quaintly humorous book, "Baddeck and That Sort of Thing," is a little village of 800 souls, far out of the traveled pathway of commerce and pleasure, where the inventor may ply matter how much the unit form is multiplied, the result maintains the buoyancy of the single cell. Kites of unlimited size can be built, and with adequate means of starting can be managed as successfully as the smallest. This is something which has never proved true with other types of construction. Dr. Bell is now able to combine tetrahedral cells so as to produce a kite forty feet wide and requiring the power of a steam tug to start it on its flight. Many of his kites are so large that he starts them by fastening the guide rope to the collar of a horse, which is whipped to a keen gallop across a long field. In a good wind such a start as this easily sends the kite soaring upward quite as buoyantly and successfully as would be the case with a small kite.

At the Baddeck laboratory, which has been fitted up without stint of expense, Dr. Bell employs a number of expert mechanics both in the construction and trial everything is ready this huge kite is towed out into the bay and her flying line made fast on board the tug, which is started ahead at full speed, twelve or thirteen knots an hour. On the first trial of this remarkable kite a heavy downpour of rain set in, and, the line being too short, there was fear that she would not fly. But no mishap occured, and the great kite, with her three boats heavily loaded with water, rose as gracefully as a bird and made a successful flight.

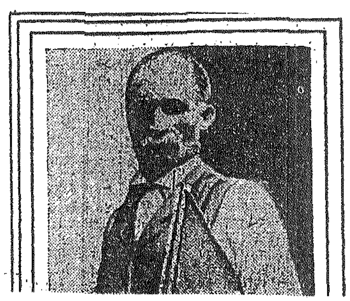
It is Dr. Bell's belief that a kite which would successfully bear aloft the weight of three or four men achieves the successful ratio between sailing surface and construction weight, and that with properly made propellers it will fly equally well under motor power as when pulled by a rope, either with a horse or a tug. The large kites have ample space in the interior for the motor and the passenger, and from the experiments already made it seems not unlikely that they possess a steadiness of flight when once started that would make them easily controllable by the operator.

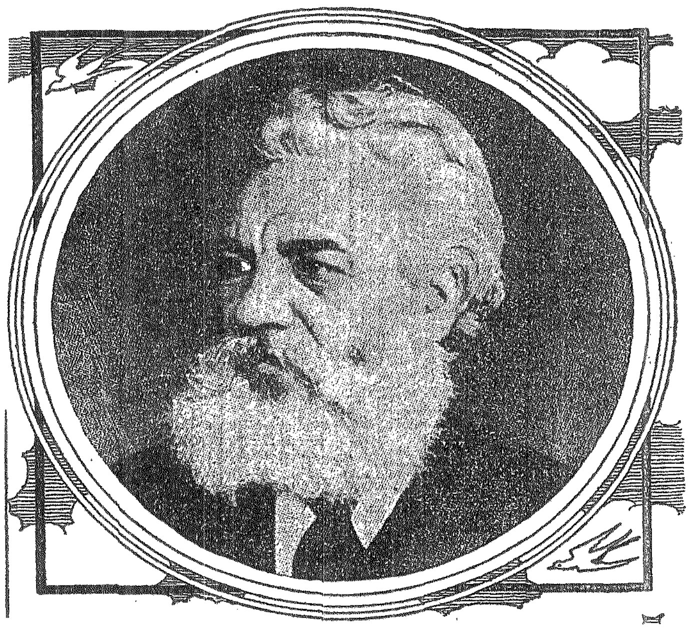
It has been found that the kites, when they reach a height of from 2,000 to 3,000 feet, encounter breezes that are much more uniform and steady in their direction and course than those which may be blowing at the time on the surface of the earth. Not infrequently it happens that when there is entire calm at the surface of the earth, the kites will enter a breeze blowing at the rate of eight or ten miles at a height of 2,000 feet.

Pictures Copyrighted by G. H. Grosvenor.



PROF BELL'S RED FLYER.





ALEXANDER GRAHAM BELL.

proached very near the time when he can make a successful flying machine. He does not regard the problem as one that cannot be solved. Whether he will succeed or not is a matter of the future, but he is confident that ultimate success has been contributed to very largely by his use of the tetrahedral kite.

CHRISTMAS IS COMING AGAIN

It Seems a Long Way Off, but the Toymakers and Dealers are Busy.

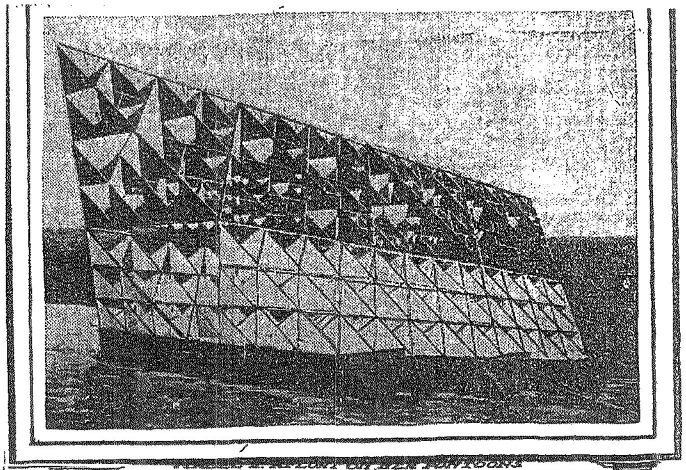
CHRISTMAS toys in April and May? absurd!" you exclaim, but for the last two months hundreds of men throughout the country have been talking and thinking little else but Christmas toys. They have about finished worrying about them now, and probably will not give them another thought until about September.

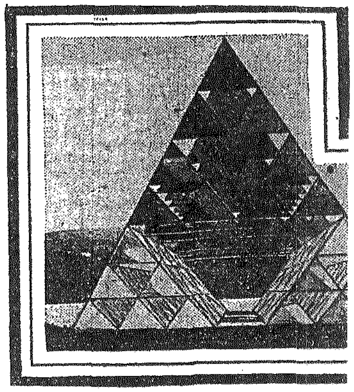
The men who have been doing all this thinking and worrying are the toy buyers for the retail stores throughout the country. They have to do their buying in February, March, and April in order that the toys may be imported for them. Very few toys are made in this country. The great majority of those used now are made in Germany, and the orders for them must be placed nearly a year ahead. In September the toys bought now will begin to arrive, and will be distributed to the purchasers.

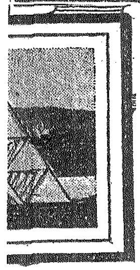
Up in Fourth Street, near Washington Square, is the wholesale toy district of New York. There are whole floors there devoted to the display of sample toys, no two alike, for the importers carry no stock. They sell from sample only, and the toys are imported on the order of the retailer or jobber. A visit to one of these big warerooms makes one forget that it is almost May. Santa Claus's sample room is a veritable fairyland, and the lucky little boy who gets a glimpse inside this room can address the Saint more intelligently when the time comes to specify the Christmas requirements. The word boy is used advisedly, for the entire ingenuity of Santa's workmen and designers this year seems to have been expended on perfecting and improving the mechanical toy, such as the American boy delights in. For girls of course there are the endless varieties of dolls of all sizes, complexions, and shades of opulence in dress. There are doll's houses of all sizes, some of them exquisitely finished and furnished, but after all these are only developments and improvements of the things with which every girl and every boy, too, is familiar.

It is in the boys' department that the Saint is bringing out his new things. What will first catch the eye, perhaps, is how the toymaker has reproduced all the attractions of Coney Island. The loop the loop is there in many forms, and the ingenuity of the German toymaker has improved upon the real thing. There is a double loop the loop which if reproduced on a large scale should prove absolutely hair-raising. Between the two loops is an elevator tower into which the car runs when it has rounded one loop. The elevator acts automatically, lifts the car to the top of the second loop, and launches it on the second round.

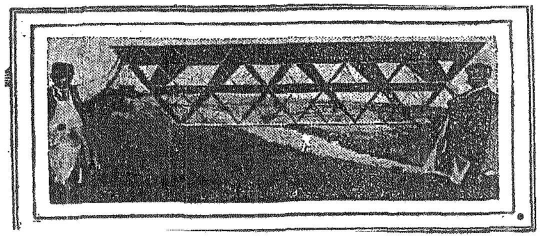
A CELL FOLDED FOR CARRYING.







END VIEW OF MABEL II.



END VIEW OF VICTOR I.

his trials of kites and motors without an ever-present throng of quizzical spectators or incredulous newspaper reporters.

When Dr. Bell first took up the study of kites he made use of the old-fashioned Hargrave box model. This was invented in 1892 by Laurence Hargrave of Australia. The box kite as a unit flies well, but when enlarged is unwieldy, and when multiplied in many units does not go together sufficiently well to encourage the use of it. Triangular kites were next tried, and later those with circular cells and with cells of six, eight, and twelve sides. None of them succeeded. The ratio between the weight of structure and the buoyant surface soon demonstrated that they could not be employed. After many failures and much careful study Dr. Bell hit upon the tetrahedron as the unit form for his kites.

Maximum of Lightness and Strength.

The tetrahedron is simply a solid figure with four faces consisting of equal equilateral triangles. The easiest way to get an idea of it is to take six sticks of equal size and length, lay three of them so as to form an equilateral triangle, stand the other three sticks at the apex of each angle, and bring the tops together. The word tetrahedron is derived from two Greek words meaning "four" and "base," as the figure has four equal bases. The result is a construction braced equally in every direction, the strongest that any unit form intended for kite construction can secure. Essentially the Chinese a thousand years ago made tetrahedral kites in form. The combination of the Chinese idea and the Hargrave scheme of multiplying units has brought out the Bell kite plan, of the kites. The framework usually is made of thoroughly seasoned black spruce. At first the sails placed on two sides of a tetrahedron were made of silk. Now they are made of nainsook, which is found to be lighter and much stronger. There is now being constructed a kite consisting of hundreds of tetrahedral cells, in which the frame is of hollow aluminium tubing. Aluminium weighs little more than the spruce, and is several times stronger. The sails are attached only at the points of the triangles. The triangles are hinged together, so that they may be taken down and carried flat under the arm. The stock of single tetrahedral cells once made, the height and breadth of the kite is wholly subject to the wish of the owner. He can make it as large as he chooses.

Dr. Bell has given names to his various large kites, calling them "White Flyer," "Mabel II.," and "Victor I." These large kites go aloft even in the slightest breeze, and show remarkable equilibrium and steadiness in spite of squalls. Usually they hold the guide rope at an angle of not less than 80 degrees. Both in the flying and in the pulling in at the close of the experiment the kites sail as steadily as a yacht. As the operator reels in the line the great mass of little triangles, looking like a flock of birds in perfect alignment, sails slowly down and alights as gently as would a bird.

Flying From the Surface of the Water.

The "White Flyer" is itself a large, three-sided pyramid made of the small tetrahedral cells. It has lifting power sufficient to sustain three or four men. "Mabel II." has been arranged with three long boats covered with oilcloth, so that the Some idea of the buoyancy of the tetrahedral kite may be gained from the statement that it has twenty-five square feet of supporting surface to each pound of weight in the structure. A wild duck, whose flight is perhaps as rapid as that of any of the bird kind, has only one-half of a square foot of supporting surface in its wings to a pound of weight. Another comparison affords some estimate of the wonderful buoyancy of Dr. Bell's kite. He has estimated that the mosquito possesses far greater powers of flight than the bird. For instance, a pound of mosquitos has an area of wing surface of forty-nine square feet. The tetrahedral kites attain fully one-half of this ratio.

Dr. Bell will resume his work on the kites this Summer, and expects to be in Baddeck by the first of June. His workmen have been engaged this year on a new kite modeled on the plan of "Victor I." which is expected to be more wonderful than any of its predecessors. "Victor I." has shown remarkable facility in starting, rising from the hand, without running, in the lightest breeze. Its model is so strong that a heavy man could stand on the apex. In other words, Dr. Bell has achieved in this new kite a lightness that, as compared to the Eddy or Hargrave kites, is as 100 to 1.

The problem involved in the use of the motor is one which must be approached very slowly. Even the remarkable engine constructed by Mr. Manley for the Langley aeroplane is not regarded as possessing sufficient strength to operate the largest Bell kite. When Dr. Bell finds a motor sufficiently strong and light, he expects to conduct a series of experiments with his windboat starting from the surface of the bay, and undertaking to ascend by skimming and making short flights at a moderate

Somewhat in line with this is the automatic aerial railway in which the car runs into an elevator at the bottom, is automatically shot up to the top again, and started on another trip.

Among the newest things are automobiles that really work. They come in all sizes, from the tiny clockwork affair that sells for a quarter up to the machine a foot or more long, operated by a storage battery, and with a clockwork chauffeur. Electricity has entered largely into Santa Claus's field this year. The boy whose tastes run to naval matters can get a battleship equipped with an electrically operated screw and a real searchlight. He can get a whole trolley system, with tracks, switches, cars, &c., all operated from the electric light wire, through the third rail system. One of the most ingenious of these electrical toys is an electric car system, in which one car stays on the switch until the other has passed, and then starts automatically.

Electricity has not altogether displaced steam however in toyland. The steam railroad is there, but railroading has given place to mechanical construction in Santa's domain. The great thing this year is the steam workshop, equipped with all sorts of power tools from the circular saw to the steam lathe. The power is furnished by an upright engine and transmitted in the regular way by belts and shafting. Some of these shops are large enough to cover an ordinary dining table, and some of the engines alone are worth $75. The various tools and other equipments can also be purchased separately.

The war game has not been neglected. The boy of military tastes can now buy a fully equipped fort, guns, garrison, and all, and he can apply electricity to working his guns, his searchlight, and all the other appliances.

Among the most interesting of the toys produced for the little tots is the ropewalker, a gayly dressed little metal man with clockwork insides and a perpetual smile, who swings from a rope in mid air by his hands and claws his way along it.

Even further down the scale of youth is the talking book. This is an old toy revived and improved. The first half of the book is just like any other picture book that tells about animals, but the last half is a box with buttons along the side. As mamma reads about the animals to baby she presses the appropriate button and the voice of the animal is heard.

There has bene a wonderful development of the doll's house. In addition to the regular dwelling, all sorts of fully equipped stores can now be bought. The mechanical idea has been applied to them, too, and one of the most interesting is the German grocery, which is closed when the little customer arrives. He presses the little push-button bell, which rings, and the shutters fly up, the door opens, and the grocery man walks out rubbing his eyes.

THE FAKIR'S REVENGE.

A FAKIR exhibiting his wares on Twenty-third Street the other day found a novel way of wreaking his vengeance on the professional shopper. The lady in question paused to inspect with interest the fighting cocks as they danced so realistically about the pavement. Then she demanded to be shown the accomplishments of the inebriated fiddler. After that she insisted that the donkeys, the seals, and the other live stock should be wound up and started on a tour up the street so that she might see which she preferred. Finally she said: "I really think the automobile is the most natural."

The man promptly wrapped up one of the shining tin toys.

"Oh, but I don't want any of them," she continued. "I just wanted to see how they worked."

which thus far is the most successful known, and seems likely to lead on to ultimate success in aerial navigation.

The tetrahedral cell possesses marvelous lightness and strength. It is braced in every direction, so that it may be constructed of the least weight of material in proportion to sailing surface. A special advantage also appears in the fact that no

kite may be started from the surface of a near-by body of water. The boats are connected by strong trusses, and resting on these are four large kites like the "White Flyer," each consisting of sixteen large tetrahedral cells. In all there are 272 cells in the kite.

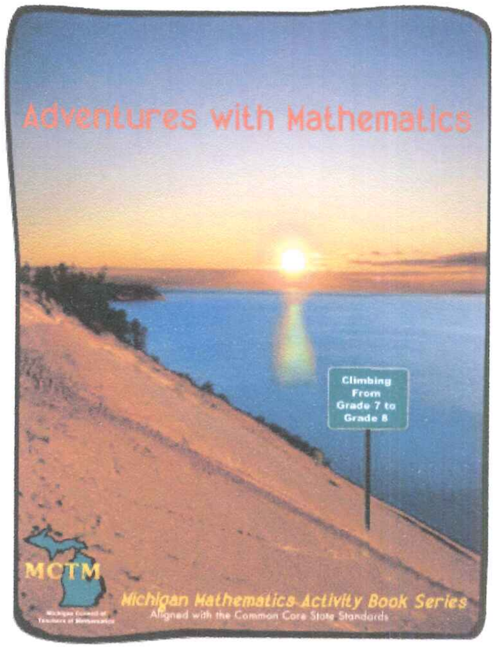
The upper tiers of the kite are of red nainsook and the lower of white. When

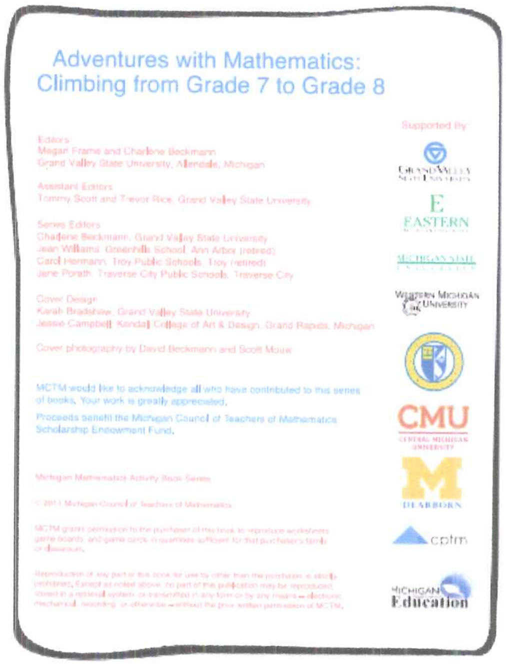
height of water, without danger to life. He will not undertake a speed greater than ten or fifteen miles an hour. As the operator gains knowledge of the emergencies that beset aerial flight he will turn on the power and increase the altitude and distance.

Dr. Bell is now very confident that he has by slow stages and great care ap-

As she turned away the fakir, choo a particularly lively seal from his co tion, wound it up and aimed it at her treating figure. Hearing the "click click" on the pavement behind her, turned and saw the avenging toy at very heels, and with a shriek she pi up her skirts and fled up the elevated s

Tetrahedral Kites Activity




Adventures with Mathematics: Climbing from Grade 7 to Grade 8

Editors
Megan Frame and Charlene Beckmann
Grand Valley State University, Allendale, Michigan

Assistant Editors
Tommy Scott and Trevor Rice, Grand Valley State University

Series Editors
Charlene Beckmann, Grand Valley State University
Jean Williams, Greenhills School, Ann Arbor (retired)
Carol Hermann, Troy Public Schools, Troy (retired)
Jane Porath, Traverse City Public Schools, Traverse City

Cover Design
Karah Bradshaw, Grand Valley State University
Jessie Campbell, Kendall College of Art & Design, Grand Rapids, Michigan

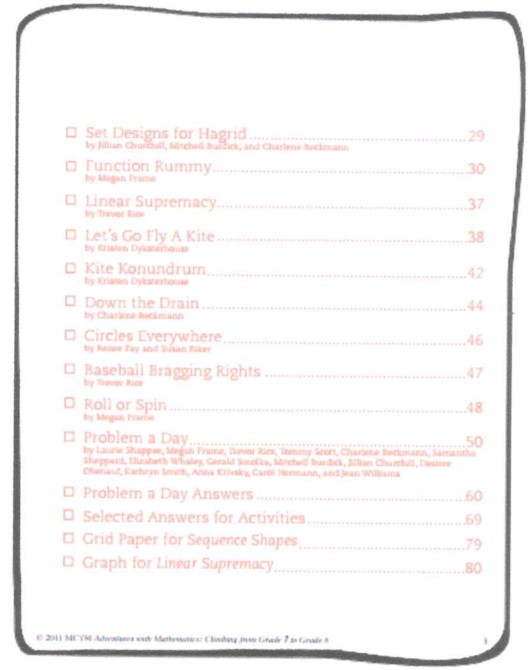
Cover photography by David Beckmann and Scott Mouw

MCTM would like to acknowledge all who have contributed to this series of books. Your work is greatly appreciated.

Proceeds benefit the Michigan Council of Teachers of Mathematics Scholarship Endowment Fund.

Michigan Mathematics Activity Book Series

Supported by



Let's Go Fly a Kite

As early as 1903, Alexander Graham Bell experimented with tetrahedral kites to design flying machines. He used the geometry of the structures to show that size and weight affect flight. He designed a tetrahedral kite wing to use in manned flight. You will create a four-celled tetrahedral kite and study its geometry to see why Alexander Graham Bell and others found it so interesting. Then, you can see how well the kite flies!

Directions...

Materials needed:

- 24 eight inch straws
- Sturdy thread
- Scissors
- Colored tissue paper 20x26 inches
- Glue stick

DUE WED. March 28th

Making a Kite:

1. Cut 4 pieces of thread approximately 40 inches long.
2. Cut 8 pieces of thread approximately 16 inches long.
3. Thread 3 straws onto one 40 inch string and tie them into a triangle making sure there is no slack in the thread. Tie the triangle such that one thread end is 4 inches long and the other thread end is 12 inches long.

   See Figure 1 at right.

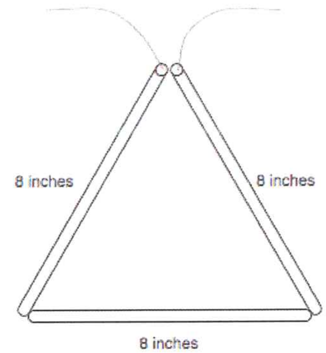
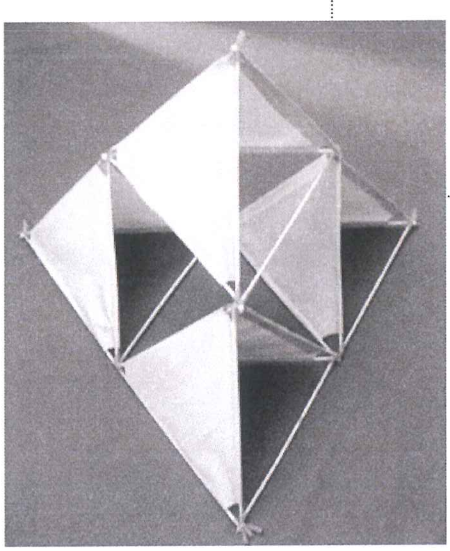


Figure 1

4. Tie a 16 inch thread to each of the two corners of the triangle that do not contain the first knot.
5. Thread a straw onto each 16" thread and tie them together making sure there is no slack. See Figure 2 below.
6. Thread a straw onto the 12 inch thread (from your first knot). Connect points A and B and tie a knot leaving no slack.

FINISHED PRODUCT!!!!



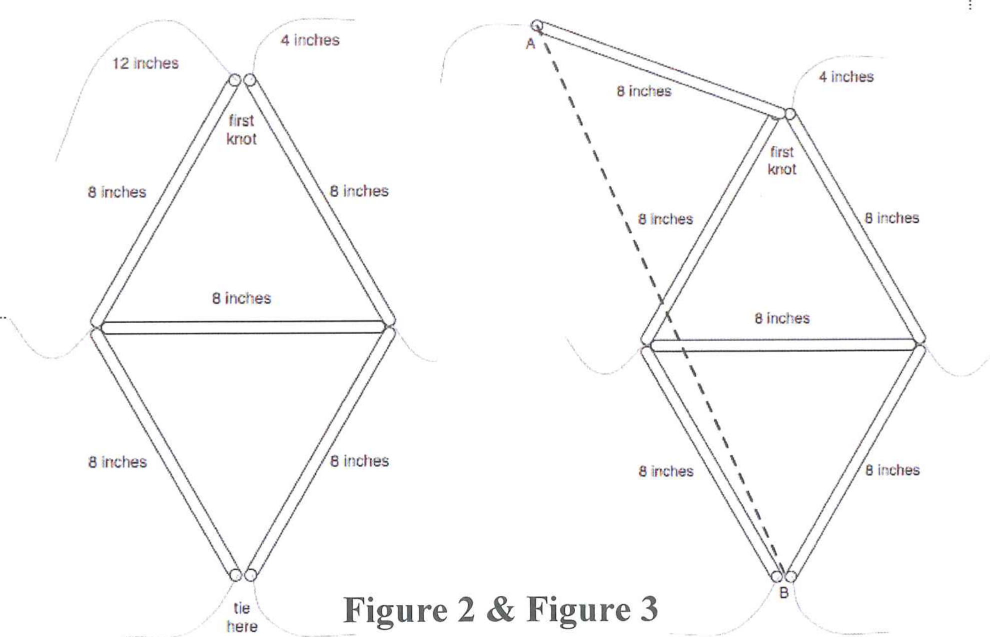


Figure 2 & Figure 3

Prepare the tissue paper for the kite as follows:

a. Carefully fold a 20 inch by 26 inch piece of tissue paper into fourths as shown in Figure 4. Each fourth is enough to complete a one-celled tetrahedral kite.

b. With the tissue paper still folded, carefully fold the fourths into fourths again as indicated in Figure 4. With the tissue paper folded into sixteenths, each section will be 5 inches by 6.5 inches.

c. Trace the template from Appendix A onto cardboard. Label the fold and cut lines on the template.

d. Keeping the tissue paper folded into sixteenths, position the template so that the edges marked fold are aligned with folds on the tissue paper. Cut along the three sides marked cut.

e. Open one section of cut out tissue paper. It should be similar to the image in Figure 5

Figure 4

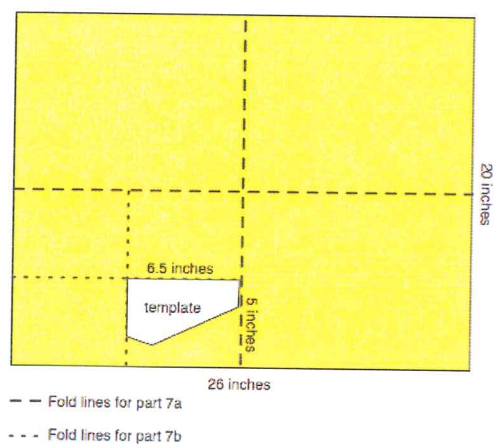


Figure 5

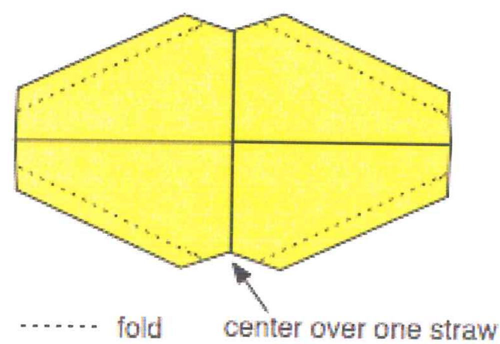
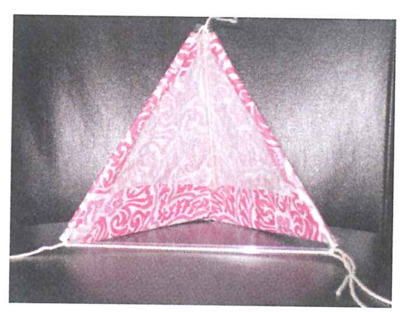


Figure 5

8. a. Center the cut-out tissue paper over one of the straws in your tetrahedral frame. Fold the edges so that they wrap around four additional straws. Note that only one straw in the frame will not be covered with tissue paper.

c. Glue the wrapped edges to the back of each triangular face.

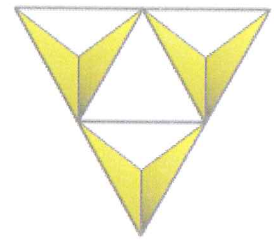
d. You have now completed a single-celled tetrahedral kite.



9. Repeat steps 1 through 6 and 8 to make three additional single-celled tetrahedral kites.

Making a 4-Celled Tetraheral Kite:

Figure 6



10. Arrange 3 tetrahedra as shown in Figure 6. Note that the covered sides of each tetrahedron need to be oriented in the same way so that the finished kite will catch the wind. Tie the bases together.
11. a. Place the 4th tetrahedon on top of and with covered sides oriented in the same direction as the other three tetrahedra.
    b. With the help of a friend or family member, tie each vertex of the base of the top tetrahedron to a top vertex of one of the base tetrahedra.
12. Your kite is almost ready for flight. Place the 4-celled tetrahedral kite on a table so the covered side is facing you. To the top tetrahedron, attach a thread from the top to the bottom vertex of the straw at the center of the tissue paper. Tie a small loop in the thread then tie the thread ends together so that there is only a little slack. You will attach the kite string to the loop, then your kite is ready to fly.

Questions….

1. Compare the face of a single-celled tetrahedron to the face of a 4-celled tetrahedron. What do you notice?

2. How many single-celled tetrahedra would you need to create a tetrahedral kite with side lengths of 3 straws?

3. If you made four of the 4-celled tetrahedral kites and connected them in the same way that you put together the 4 single-celled tetrahedral kites to make a 4-celled kite, what shape would you have? How many single-celled tetrahedra would you need?

4. Imagine, draw, or build each new size of tetrahedral kite by adding layers of single-celled kites to the next smaller size. Each new kite is itself a tetrahedron. Fill in the table. Let a unit of length equal the length of a straw. Unit Triangle refers to a triangle whose side length is 1 straw on each side.

Length of a Side (measured in straws)	**Perimeter of a Face** (measured in straws)	**Number of Unit Triangles on Each Face**	**Total Number of Unit Triangles on Kite Surface**	**Number of Single-Celled Kites on Bottom Level of Kite**	**Number of Single-Celled Kites Needed for *n*-Celled Kite**
1	3	1	4	1	1
2	6	4	16	3	4
3					
4					
n					

5. What patterns do you notice in the table?

6. How many straws are needed to make a kite with 10 straws on a side? How many unit tetrahedral kites would you need? How do you know?