Developing Instructional Media for Primary School Mathematics Teaching and Learning

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Contents

Introduction

Learning mathematics is the development of new mathematical knowledge, skills, or attitude toward mathematics, which happens when a student interacts with information and environment. In this context, we are concerned with the students' learning that takes place in response to instructional efforts involving the selection, arrangement, and delivery of information in appropriate environment by teachers or students. Learning environment includes a place where instruction takes place, physical facilities, psychological atmosphere, technology, methods, and media needed to convey information and guide the learner's study.

Teachers need to use an eclectic approach to learning. The successful instructional practices should have features that are supported by virtually all the various perspectives: (1) active participation, (2) practice, (3) individual differences, (4) feedback, (5) realistic contexts, and (6) social interaction (Smaldino, SE et. al, 2009: 7-8). In active learning students are actively engaged in meaningful tasks and interacting with the content. New learning requires more practices in various contexts that will improve the rate of retention and the ability to apply new knowledge, skill, or attitude. The use of effective methods in instruction allow individuals with different personality, general aptitude, knowledge of subject, to progress at different rates, cover different materials, and even to participate in different activities. Giving feedback during teaching and learning enables learners to know if their thinking is on track. The use of real-world context in learning environment helps students to remember and to apply knowledge. Meanwhile, learning by interacting with tutor, peers provides a number of pedagogical and social supports.

In relation to the above perspectives, teachers may use instructional media in classroom to facilitate students' learning and to give them those perspectives. By instructional media here are all materials (physical hardware and software) and tools that teachers may use in their lesson to facilitate students in achieving the instructional objectives. It covers a wide range of materials and apparatuses, and usually classified into visual, audio, video, and its combinations.

In general, media (single: medium) are tools used to transfer information or messages from the source to the receiver. Media used in the communication processes, including teaching and learning process. According to Wayan Santyasa (2007: 3), teaching and learning process contains five communication components, namely teacher (communicator), instructional materials, instructional media, students (communicants), and instructional objectives. Instructional media are integral parts of instructional system, meaning that it can not be separated from learning process.

Instructional media include traditional media (chalk board, textbook, handout, module, poster, student worksheet, real objects, manipulative, OHP slide, video tape, life creature, etc.), mass media (newspaper, magazine, radio, television, movie, etc.), and new ICT-based instructional media (computer, CD, DVD, interactive video, Internet, multimedia system, video conference, etc.). There are also some classifications of media, but this paper will focus on the development of more specific ones, manipulative, that teachers can easily develop for their instructional purposes.

Analyzing Mathematics Primary School Curriculum and Its Media Needs

The use of instructional media in classroom should be based on the appropriate judgment that it can facilitate students learning or student understanding on the learning materials. Therefore, teachers need to analyze the curriculum contents and make right judgment about which media are appropriate to support students learning on the contents. Heinich, Molenda, dan Russell (1985) remind mathematics teachers: "…that the business of education is not learning, but the management of learning, that is, instruction. The teacher organizes the experiences of learners in a way that helps them change their performance in a meaningful way." Therefore, the teaching of mathematics should help learners to:

1. Learn mathematics meaningfully or learning with understanding. Students should be facilitated to construct their knowledge based on their previous knowledge.
2. Learn mathematics joyfully. Students should be facilitated to learn mathematics in novelty, pleasure, and in unthreatening situation.
3. Learn mathematics to help them to learn to think. Students should be facilitated to start the learning process to solve the problem or activity proposed by teacher.
4. Learn mathematicsto help them be independent. Students should be facilitated to solve the problem or activity independently.

To meet the four important tasks above, every mathematics teacher and educator should be facilitated to improve his/her competency to produce such high quality of teaching and learning resource materials (including in using and implementing the resource materials from internet) for mathematics teachers (including in designing Lesson Plan that starts with activities or contextual/realistic/mathematical problem and hypothetical learning trajectory) as real examples for mathematics teachers.

The points can be learnt from Shadiq (2016) are as follows:

1. Start the teaching and learning with an activity, task, or problem to ensure that students learn to think.
2. Start with activity/task that students already learn its preexisting or prior knowledge to ensure that student learn meaningfully or learn with understanding.
3. Let students to explore to ensure that students learn mathematics by/for themselves. Use inductive and deductive thinking.
4. Let students to communicate to ensure that students learn and learn also from each other's.
5. The role of a teacher is to facilitate and not just transferring knowledge from the mind of the teacher to the mind of the learner

6. Students are actively involved in the learning process and not as the passive receiver of the knowledge
7. Besides learning mathematical content, children should also be facilitated in enhancing their capacities in mathematical process and attitudes/values.
8. The mathematical process/skills can be in the form of observing, looking for pattern, conjecturing, questioning, investigating/exploring, solving problem, and communicating.
9. The mathematical attitudes/values can be in the form of accepting the beauty of mathematical pattern, increasing the curiosity, evaluating the reasonableness of the result and appreciating the value of mathematics.
10. If we agree that our students should learn not only mathematical content knowledge then we should decrease the content knowledge from our curriculum.
11. The practice of examination can be used to ensure that the practice of teaching and learning of mathematics will help our students to be independent learner and creative citizens.

The format can be used in Analyzing Mathematics Primary School Curriculum and Its Media Needs is as follow:

No	**Topics**	**Sub Topics**	**Students' difficulties**	**Teaching Aids/models/puzzle/manipulative/ games/Comics/bulletin/Art**	**Notes/Description of Teaching Aids Picture**

Or in this format:

Topics:
1. Sub Topics:
2. Students’ difficulties:
3. Teaching Aids/models/puzzle/manipulative/games/comics/bulletin/Art:
4. Notes/Description of theTeaching Media:
5. Diagram/Pictures:

It is important to remind mathematics teachers or teachers that in Analyzing Mathematics Primary School Curriculum and Its Media Needs should be based on teacher experiences, especially on Students’ difficulties during the teaching and learning of mathematics, and also on the advantages of Teaching Aids/Models/Puzzle/Manipulative/Games/Comics /Bulletin/Art that can be used and implemented during the teaching and learning of mathematics and also on minimize the disadvantages of the teaching materials. Once again, the media can be used to help and facilitated learners to learn mathematics: meaningfully, joyfully, learn to think and to be independent learners.

Developing Media for Primary School Mathematics Teaching and Learning

The following are basic steps in developing instructional media (Scanlan, n.d.):

1. analyze the curriculum contents, instructional goals, objectives, audience and instructional strategy;
2. determine what kind of medium (media) is/are the best to support students learning on that contents;
3. search for and review existing media/materials;
4. adapt existing media/materials if necessary;
5. if new media/materials need to be developed:
    a. determine the format, design, colors, size, etc;
    b. determine the most appropriate materials to create the media;
    c. create the media;
6. implement/apply or try it out; and
7. evaluate/revise.

When developing instructional media, teachers should also consider several factors. They are nine factors, namely: institutional resource constraints, course content appropriateness, learner characteristics, professor attitudes and skill levels, course learning objectives, the learning relationships, learning location, time (synchronous versus asynchronous), and media richness level. These nine factors can be summarized into three factors (Scanlan, n.d.), namely: practicality, student appropriateness, and instructional appropriateness.

The **practicality** of media is evaluated based on media availability, its cost and time efficiency, and understood by teachers. The student **appropriateness** of media addresses the development and experience level of students. The **instructional appropriateness** of media is evaluated using the planned instructional strategy, the efficiency and effectivity of implementation of the lesson plan when using the media, and the students' acquisition of the specific learning objectives when facilitated with the media.

Gagné, Briggs, and Wager (1992) as cited by Scanlan (n.d.), suggest that teachers should address the following practical questions to evaluate the practicality and student **appropriateness** of instructional media.

1. How many students are in classroom?
2. What is the range of viewing and hearing distance for the use of the media?

3. How easily can the media be "interrupted" for pupil responding or other activity and for providing feedback to the learners?
4. Is the presentation "adaptive" to the learners' responses?
5. Does the desired instructional stimulus require motion, color, still pictures, spoken words, or written words?
6. Is sequence fixed or flexible in the medium? Is the instruction repeatable in every detail?
7. Which media provide best for incorporating most of the conditions of learning appropriate for the objective?
8. Which media provide more of the desired instructional events?
9. Do the media under consideration vary in ‘affective impact’ for the learners?
10. Are the necessary hardware and software items obtainable, accessible, and storable?
11. How much disruption is caused by using the media?
12. Is a backup easily available in case of equipment failure, power failure, film breakage, and so on?
13. Will teachers need additional training?
14. Is a budget provided for spare parts, materials, repairs, and replacement of items that become damaged?
15. How do cost compare with probable effectiveness?

Scanlan (n.d.) cited some typical questions that can be used to decide on the the **instructional appropriateness** of instructional media.

1. What kind of students activities required to achieve the learning objectives?
2. What kind of instructional media are best to use to support the students activities?
3. What kind of learning materials already available to use?
4. Should teacher consider using more than one technology or medium? Will they augment one another or detract from one another?
5. Can student location, work schedule or other factors of access be addressed by the use of available technology?
6. Do teachers need to teach students how to use the media?
7. Does teacher have the skills needed to produce effective media? Do I have the resources to learn?
8. Can the medium be produced by the time it is needed?
9. Can the production, maintenance and operation costs be afforded?
10. Does the medium fit the policies/programs at the school?
11. Is the medium a practical choice given its environment?
12. Is the technology needed to use readily available? Is it easy to use?
13. What is the main benefit to me of using the media?
14. What are the benefits for students?

Regarding the appropriateness of instructional media, Scanlan (n.d.) also cited the Gagné, Briggs, and Wager's exclusion and inclusion criteria (1992) in selecting media for the various common learning outcomes.

Learning Outcome	Inclusion	Exclusions
Intellectual Skills	• Use media providing feedback to learner responses	• Exclude media having not interactive feature
Cognitive Strategies	• Use media providing feedback to learner responses	• Exclude media having not interactive feature
Verbal Information	• Use media able to present verbal messages and elaboration.	• Exclude only real equipment or simulator with no verbal accompaniments.
Attitudes	• Use media able to present realistic picture of human model and the model's message	• Exclude only real equipment or simulator with no verbal accompaniments.
Motor Skills	• Use media making possible direct practice of skill, with informative feedback	• Exclude media having no provision for learner response and feedback

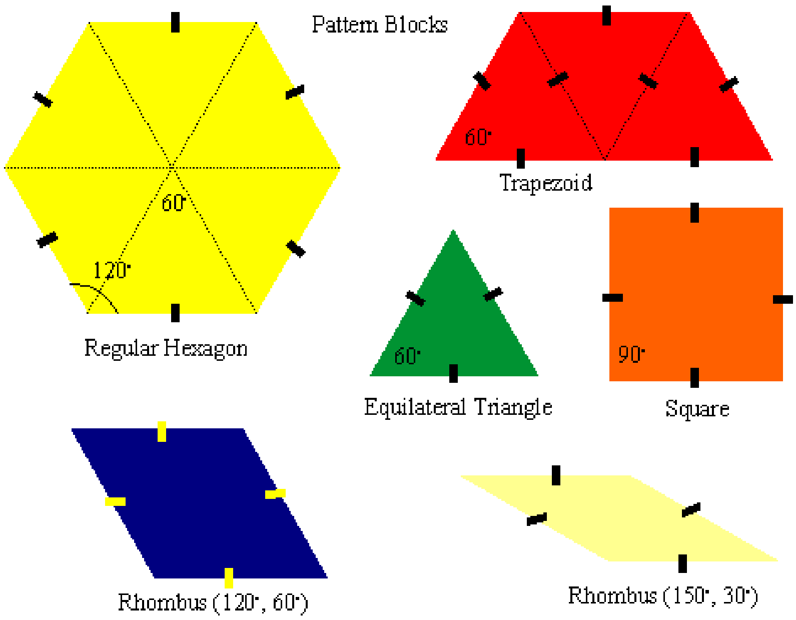
When teachers want to use or develop instructional media, they have to consider the available constraints. Dick, Carey, & Carey (2001) as cited by Scanlan (n.d.) specify three major constraints, namely: **(un)availability of materials**, **production constraints**, and **instructor facilitation**.

Using existing instructional materials can facilitate the creation of instructional units; however, if no appropriate materials exist, then the teachers must create the materials. This usually leads to a production constraint. Creating quality instructional media can be a costly, in both time and money, enterprise. A central question to answer is what level of media quality is acceptable, that is, both time and cost efficient as well as instructionally effective. Most forms of instructional media involve teacher modeling, demonstration, implementation, or more broadly, facilitation. The amount or difficulty of these processes of media facilitation may inhibit a teacher's ability to effectively utilize the particular media.

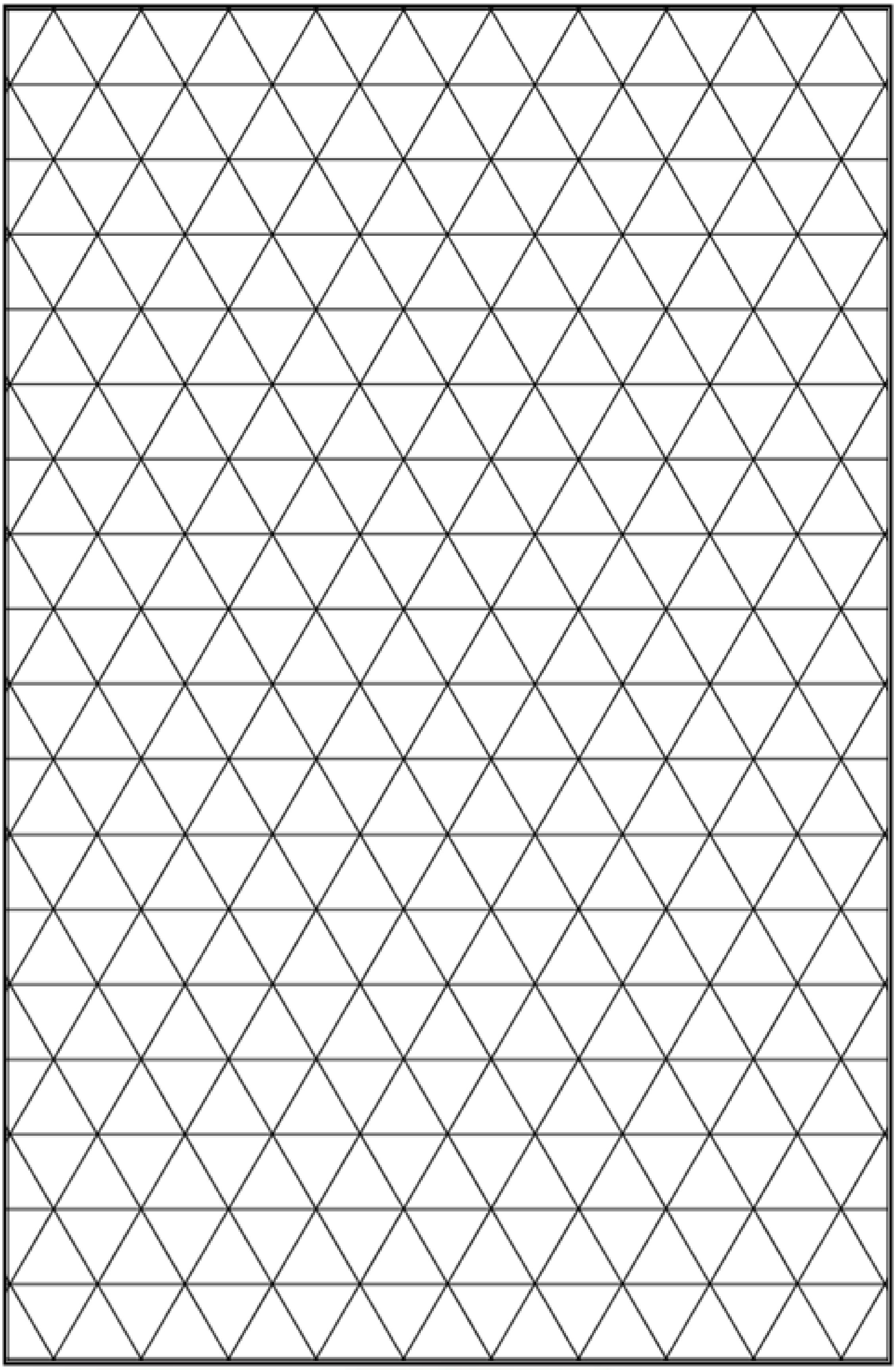
Media for teaching and learning mathematics include manipulative. Teachers may develop manipulative by themselves, or they can ask their students to create manipulative under teachers' guidance. The following are some examples of hand-made manipulative that can be created by teachers or students. When developing media for teaching and learning mathematics, teachers should also design the related activities for students to learn and to explore the appropriate topics. Please be noted that the given activities are just as examples, teachers may adjust or modify it for use in their own classes based on students levels.

A. Triangle Grid and Pattern Blocks

The triangle (isometric) grid can be printed on a board or a thick paper. Teachers may design triangle grid on a paper sheet. It can be designed with different sizes or scale, for example, using grid size of 1 cm, 2 cm, 3 cm, 4 cm, and so forth. Similar to the Cartesian (square/rectangular) grid, the isometric grid can be used for multiple purposes in mathematics. It can be used to design many geometric shapes, such as the **Pattern Blocks**.



A Set of Pattern Blocks



Triangle Grid

The Pattern Blocks consists of six different geometrical shapes: equilateral triangle, square, rhombus (120^o, 60^o), rhombus (150^o, 30^o), regular hexagon, and 3-side equal trapezoid. All shapes, except the trapezoid, have the same length of sides as the sides of the equilateral triangle. The following are some examples of activity using the Pattern Blocks or Isometric Grid.

Activity Using Pattern Blocks: Warm Up Activity

Objectives*:*

1) To manipulate triangles, squares, hexagons, trapezoids, and rhombuses to learn the names of the polygons and associate the names with the correct polygons.
2) To listen and respond to directions using the names of the polygons.

Materials*:*

1) The Pattern Blocks
2) Isometric Grid Paper
3) Cardboard or manila folder dividers

Procedure:

Students may work in pairs or groups of 3 or 4. This activity could also be introduced to the class with one person giving directions and individuals or groups of students responding.

1) Start with two different blocks, each 2 pieces.
2) One student in the group (or pair or class) – as the **Mission Control** – constructs a pattern using the specified number of blocks on the triangle grid paper, and don't show it to the other participants – as the **Space Ship Crew Members**.
3) The Space Ship Crew Members are on a mission and have encountered problems - they have only one-way communication with Mission Control! In order to find their way home they must follow Mission Control's orders exactly to rebuild their panel of controls.
4) Remind all students that there is only **one-way** communication, which means ONLY Mission Control may speak!
5) Looking at the "panel" of shapes, Mission Control carefully describes the position of the shapes using as much vocabulary as possible to assist the Crew in constructing the panel, which will enable them to return to Earth.
6) As Mission Control speaks, the Crew Members listen and construct the panel using Mission Control's description.

Processing*:*

1) All students compare their control panel to that of Mission Control. If it is exactly the same, they return to Earth. If it is not exactly the same, they are lost in Space!
2) Discuss how precise vocabulary can be very helpful. Make a list (available for everyone to see) to assist in subsequent games.
3) As skill in describing the configurations improves, add more blocks to the panel until all six different polygons have been used.

Describe the Shape

Objective:

Students will learn to identify a square, triangle, rhombus, trapezoid, and hexagon.

Manipulative Activity:

1) Distribute squares to all students in the class. Hold up the square and ask the students to describe the shape. Write the students' responses on the board. Say the name of each shape and have the students repeat it.
2) Do the same procedure for each one: square, triangle, rhombus, trapezoid, and hexagon.
3) Ask students to use **the triangle grid paper** to design a pattern block.
4) Students color and list the shapes used.
5) Students draw their own design using pattern block shapes and write a story about it.
6) Ask students to identify: triangle, rhombus, trapezoid, and hexagon.

Making Patterns

Objective:

Students will learn to create patterns using squares and triangles.

Manipulative Activity:

1) Draw a pattern on the chalkboard and ask the students to describe the pattern using the names of the shapes.
2) Distribute the triangle and square blocks. Have the students create a pattern using the triangles and squares, and draw and color their patterns on triangle grid paper.
3) Repeat the activity using different shapes.
4) Ask students to use **the triangle grid paper** make some pattern block design sand have a partner guess what each pattern is.
5) Students can write about a pattern that they use every day.

6) As students to make a pattern:
   a) using only triangles;
   b) using only triangles and hexagons;
   c) using all of the shapes: triangles, rhombuses, trapezoids, and hexagons;
   d) covering the entire page.

Building Shapes

Objective: Students will learn to find all of the different ways to build a hexagon.

Manipulative Activity:

1) Distribute hexagonal shapes and the triangle grid papers to pairs of students. Ask students to name and describe the shape. Distribute three rhombuses, two trapezoids, and six triangles to each pair of students and have them find all the different ways to put the shapes together to make a hexagon. Have students draw and color one example on the paper.
2) Ask students to draw hexagons on the triangle grid paper and color the hexagons to show how other shapes were combined to make hexagons.
3) Students identify signs in the neighborhood.
4) Students design a sign using a hexagon.
5) Ask students to find all the different ways to put the shapes together to make a hexagon and how many of each shape needed to make a hexagon:
   a) ____ a triangle,
   b) ____ a rhombus,
   c) ____ a trapezoid,
   d) ____ a hexagon.

Using the Pattern Blocks: Investigating Tessellations

Objectives:

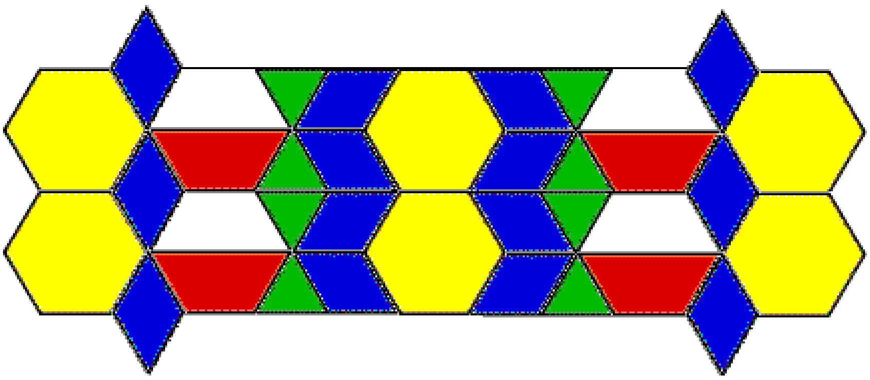
1) To manipulate triangles, squares, hexagons, trapezoids, and rhombuses to see how they might combine to form patterns in the plane.
2) To consider which of these patterns are tessellations and which are not using the definition that a tessellation is a tiling with shapes that cover the plane without gaps or overlaps.
3) To consider which of these patterns are **regular** tessellations and which are not using the definition that a **regular** tessellation is a tiling with shapes that cover the plane in a regularly repeating pattern without gaps or overlaps.

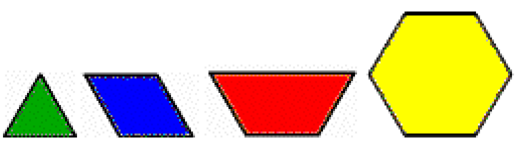
Procedure:

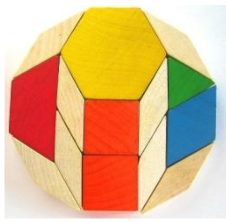
1) Instruct the students to make patterns with the blocks, making sure that they leave no gaps or spaces.
2) After each student or group of students has a pattern, have all of the students rotate around the room to view each others' products.
3) Discuss the patterns.
4) Discuss the relationships between the blocks.

Questions:

1) Which shapes fit together easily?
2) Which shapes don't seem to fit with the others?
3) Which patterns could be repeated over and over again in the plane?
4) What shapes fit together making a pattern using only one type of block?
5) What shapes fit together making a pattern using two blocks that are different?
6) What shapes fit together making a pattern using three blocks that are different?





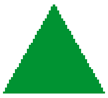


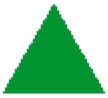
Using Pattern Blocks: Working with Fractions (What's My Number?)

Objective:

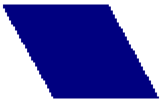
Students will determine the size of an object given the size of 1 unit.

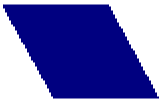
Ask students to use the pattern blocks and the pattern block grid to complete the following activity. Ask them to draw their answers on a piece of triangle grid paper. Then, ask them to write a summary of what they investigated in this activity.

1) If  is $\frac{1}{2}$ of a unit then draw 1 unit.

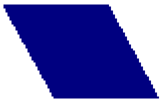
2) If  is $\frac{1}{2}$of a unit then draw $2\frac{1}{2}$ units.

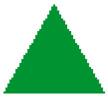
3) If  is $\frac{1}{2}$ of a unit then draw 1 unit.

4) If  is $\frac{1}{3}$ of a unit then draw 1 unit.

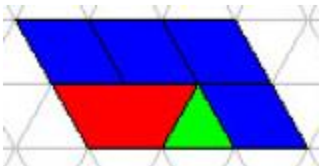
5) If is 3 units then  is _____________.

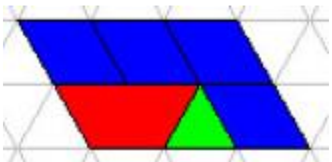
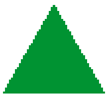
6) If  is 1 unit then is _____________.

7) If  is 1 unit then  is _____________.

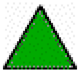
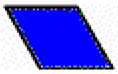
8) If  is 1 unit then  is _____________.

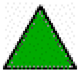
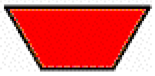
9) **More**

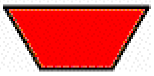
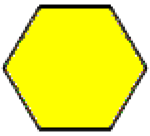
   a. If  is 1 then  is ____________.

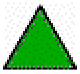
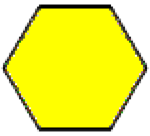
   b. If  is 1 then  is _____________.

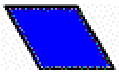
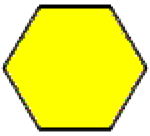
Use the pattern blocks to answer the following questions.

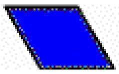
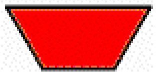
1) How many  are in  ? ______________

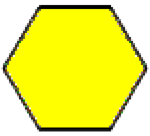
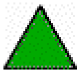
2) How many  are in  ? ___________

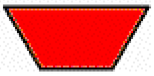
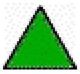
3) How many  are in  ? _______________

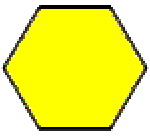
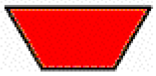
4) How many  are in  ? _______________

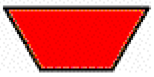
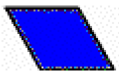
5) How many  are in  ? _______________

6) How many  are in  ? _______________

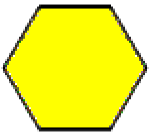
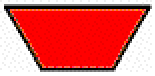
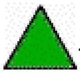
7) If  = 1,  = _______________.

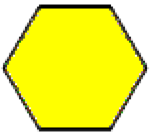
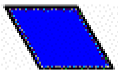
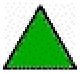
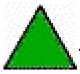
8) If  = 1,  = _______________ .

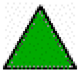
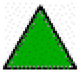
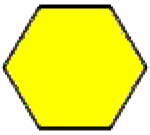
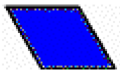
9) If  = 1,  = _______________ .

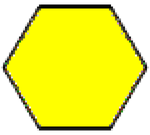
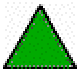
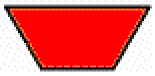
10) If  = 1,  =_______________.

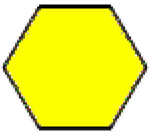
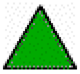
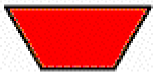
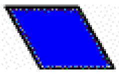
More Fun Fractions – Let's do some *really* fun ones.

1) If  +  = 1, what is ? ______________

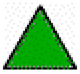
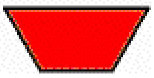
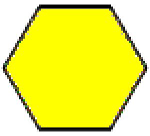
2) If  +  = 1, what is  + ? ______________

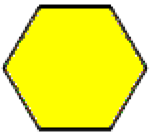
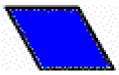
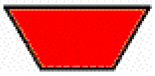
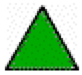
3) If  +  = 1, what is  +  ? ______________

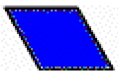
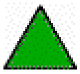
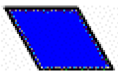
4) If  +  = 1, what is  ? ______________

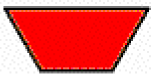
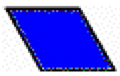
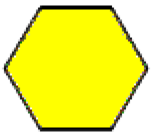
5) If  -  = 1, what is  +  ?
____

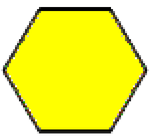
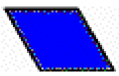
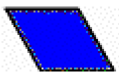
Answer the following questions with the appropriate blocks. (Answers are given)

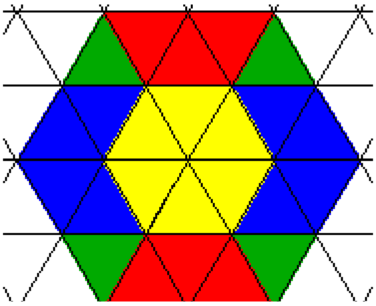
1) If  +  = 2/3, what is 1? 

2) If  +  = 4/5, what is 2/5?  + 

3) If  +  = 3/4, what is 1/2? 

4) If  +  = 5/8, what is 3/4? 

5) If  -  = 1 1/3, what is 2/3 ? 



Multiple Choices. Look at the above design constructed using the pattern blocks.

- What fraction of the design is blue?

    A. 4/24= 2/12 = 1/6

    B. 6/24 = 3/12 = 1/4

    C. 8/24 = 4/12 = 1/3

- What fraction of the design is red?

    A. 4/24 = 2/12 = 1/6

    B. 6/24 = 3/12 = 1/4

    C. 8/24 = 4/12 = 1/3

- What fraction of the design is yellow?

    A. 4/24 = 2/12 = 1/6

    B. 6/24 = 3/12 = 1/4

    C. 8/24 = 4/12 = 1/3

- What fraction of the design is green?

    A. 4/24 = 2/12 = 1/6

    B. 6/24 = 3/12 = 1/4

    C. 8/24 = 4/12 = 1/3

Ask students to use the four shapes (triangle, trapezoid, hexagon, rhombus), each in a certain number, and their colors to design a figure on a triangle grid paper, then ask them to calculate the fractional part of each color.

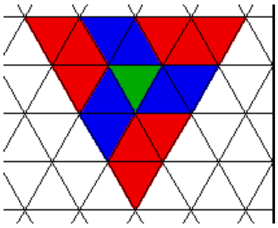
Designer Fractions - Symmetry

Symmetry is a very important concept in mathematics which can be observed frequently in nature. In mathematics, symmetry is an interesting property that has many applications not only in mathematics itself, but also in other fields of study.

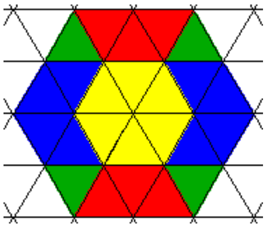
There are several types of symmetry. One is the line symmetry. Consider about human body. If we draw a line down the center of human body from the top of head to the bottom of feet, the body on one side of the line would be almost identical to the part on the other side of the line. If they were exactly identical, we'd call the line **a line of symmetry**. A design or object has line symmetry if, when we draw a line across the middle, the half part is a mirror image of the other half part. Would a line across your waist be a line of symmetry?

A line of symmetry can be considered as a fold line. If we fold a figure on the line of symmetry, the figure will fold right in half, with both sides right on top of each other. Some figures have more than just one line of symmetry, and some have none. Consider the 3 and 4 colored designs below. First investigate the symmetry including the colors inside. In other words, red would have to fold onto red. How many lines of symmetry does each figure have?

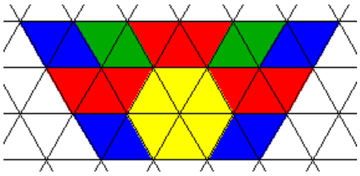
Would your answers be different if you considered just the outline of the figures? Why don't you give it a try? How many lines of symmetry would each figure have if you ignored the inside and just considered the outline?



(3 lines of symmetry outline)



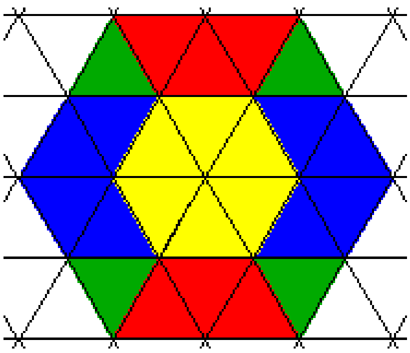
(6 lines of symmetry outline)



(1 line of symmetry outline)

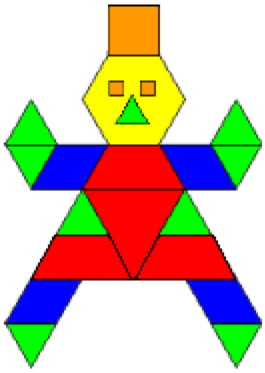
Symmetry Can Save Work

Look at the design beside. What is the total number of triangles in the design? What fraction is each color representing? Observe that using a line of symmetry property, the top half is identical to the bottom, so we only need to count the top half (or bottom half). There are 3 yellow triangles in the top, and 12 triangles in all in the top. So the fraction of yellow is 3/12. Without using the line symmetry property, we counted 6/24, which is equal to 3/12.Therefore, using symmetry property is saving our counting work.



Actually, because the design has two lines of symmetry (by considering the colors), and if we work with fractions, we can really save our work more. Just look at a fourth of the figure (formed by the two lines of symmetry), and see that there are two blue triangles out of six triangles in all (Add the 1/2 yellow and 1/2 red to make six total). That is equal to the 8 out of 24 in all resulting1/3.

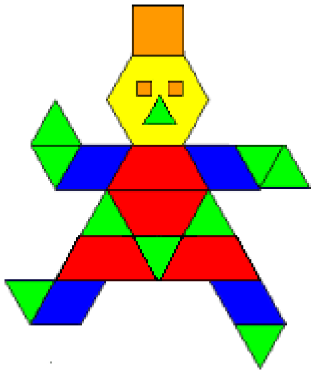
Line Symmetry Activity



1) Distribute pattern blocks or isometric paper and have students create designs that have line symmetry.
2) After doing activities, ask students to define line symmetry.
3) Ask students to fold paper in half and paint a design on one side of paper.
4) Ask students to fold again and identify where the line of symmetry falls.

Rotational Symmetry Activity

Objective: to show rotational symmetry using pattern blocks.



Give some examples of objects that have rotational symmetry and turn it around. Ask students to observe what happen. Ask them to define what rotational symmetry is. For example, to demonstrate, take three triangles and put a dot within the same angle on each triangle. Ask a student to "rotate" the second triangle so that the dot has moved, but the triangle looks the same. Ask another student to "rotate" the third triangle so that the dot is not in the same position as in either the first or second triangle, but the triangle looks the same. Continue this demonstration with squares, hexagons, trapezoids, and rhombuses (How many of each are required?). Do all of these shapes have rotational symmetry?

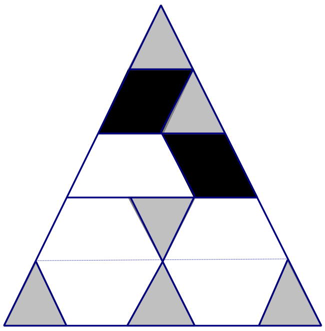
Here are some possible activities related to the rotational symmetry and pattern blocks.

1) Students use **pattern blocks** to create rotational symmetry and use **the triangle grid paper** to color in the designs.
2) Students define rotational symmetry.
3) Students write about things in the environment that have rotational symmetry.
4) Students collect pictures from news paper or magazines and make a book about things that have rotational symmetry.

Pattern Block Fraction Values

1. If each triangular piece costs $1.00, how much will the whole large triangle cost?

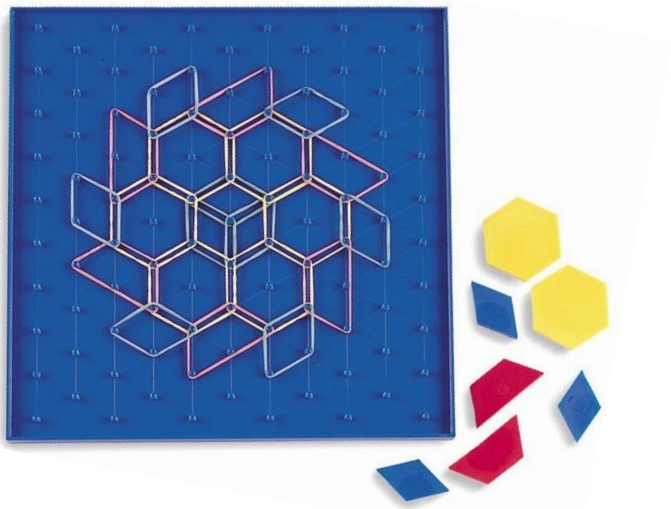
Name of Piece	Cost



2. If the whole large triangle costs $1.00, how much will each piece cost?

Name of Piece	Fraction of Cake	Cost

B. Pattern Block Array Geoboard

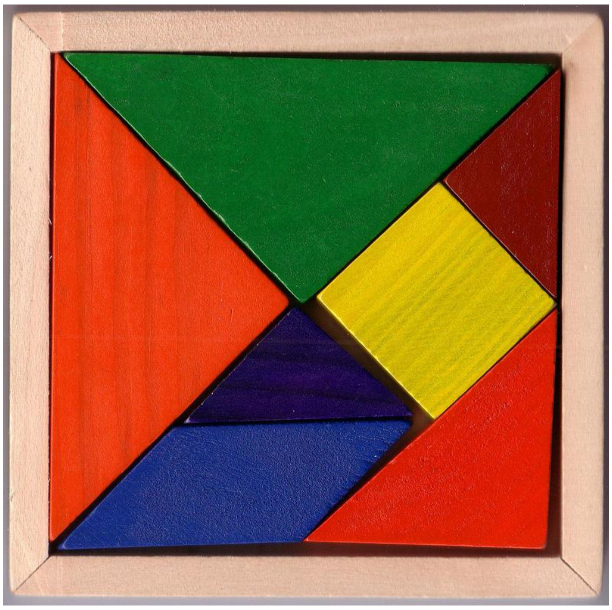


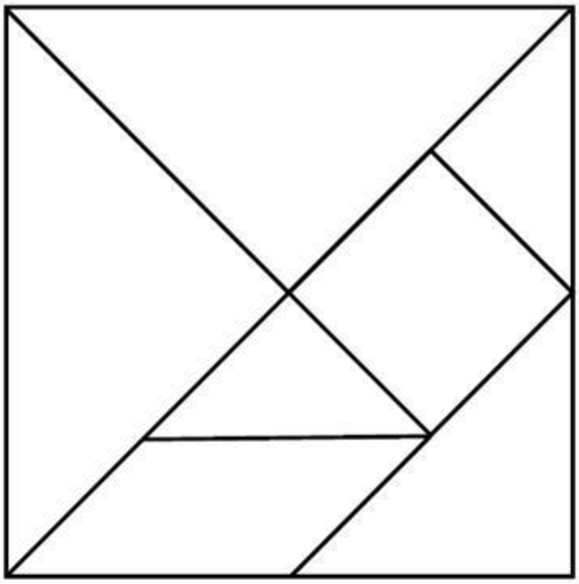
- This geoboard can be made from a square-form wood or other tight enough material.
- Use umbrella-head pins to make array of 10x11 pins arranged in order to keep rubber bands in place as students create designs, as shown in the picture.
- Use isometric models to allow for construction of hexagons and equilateral triangles.

The geoboard offer opportunities for hands-on exploration of geometric concepts using rubber bands, including shapes, symmetry, congruency, area, perimeter, coordinates and spatial relationships. The activities of using this learning media are similar to those of using the triangle grids.

C. Tangrams

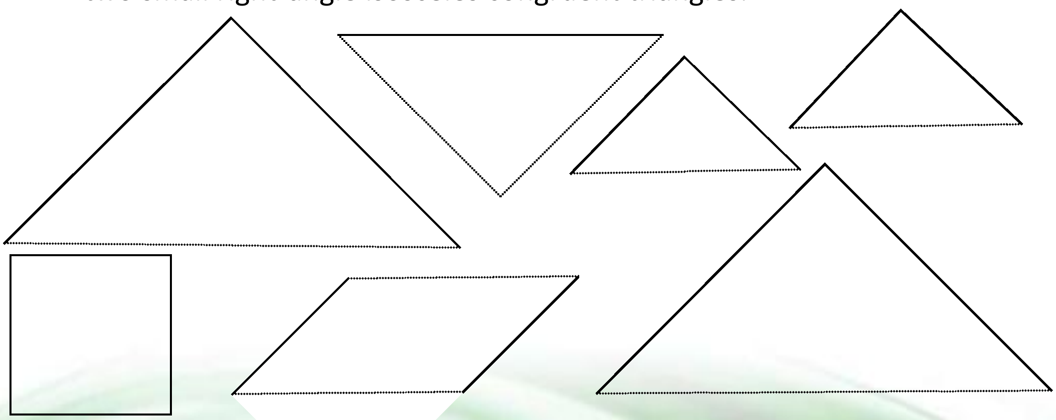
Tangram is a traditional Chinese puzzle made of a square divided into seven pieces (two large right-angle isosceles congruent triangles, one medium right-angle isosceles triangle, one square, one parallelogram, and two small right-angle isosceles congruent triangles) that can be rearranged without overlap to match particular designs or to form a great variety of other figures. It can be made from a piece of paper, wood, foam, mica or thick plastic.





A **complete set of tangrams** consists of seven pieces:

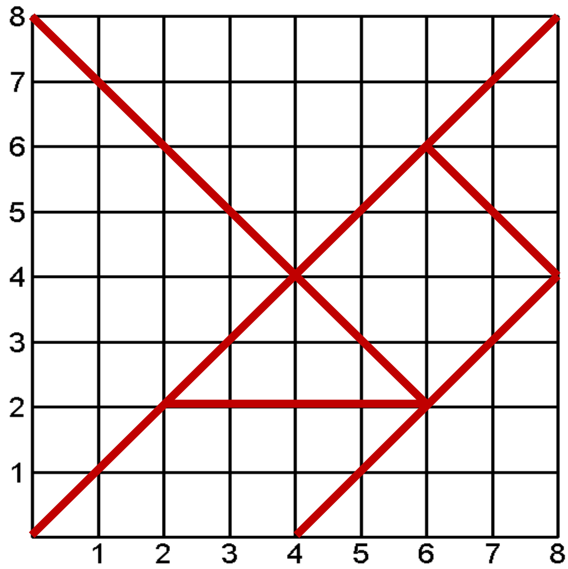
- two large right-angle isosceles congruent triangles,
- one medium-size right-angle isosceles triangle,
- one small square,
- one parallelogram, and
- two small right-angle isosceles congruent triangles.



Creating Tangrams from a Coordinate Grid

1) Connect (0,0) and (8,8). Lift pencil.
2) Connect (4,0) and (8,4). Lift pencil.
3) Connect (0,8) and (6,2).Lift pencil.
4) Connect (2,2) and (6,2). Lift pencil.
5) Connect (6,6) and (8,4). Lift pencil.

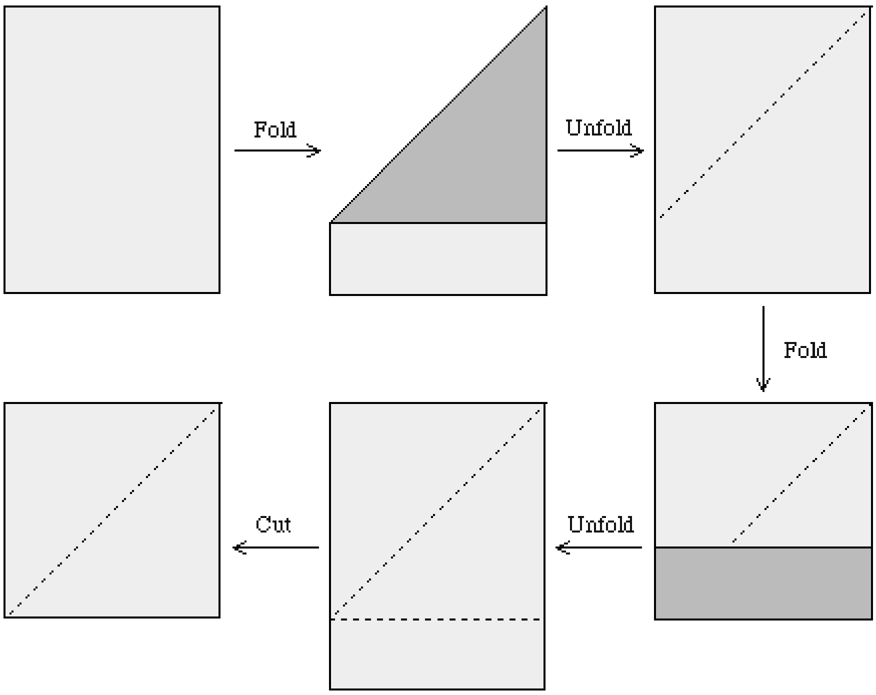
Cut out the pieces of the square. This is your very own tangram set.



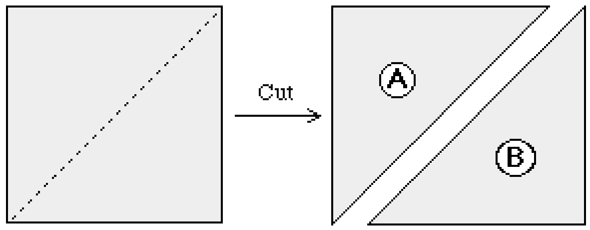
Constructing a Set of Tangrams from a Piece of Paper

To constructs a set of tangrams from a single rectangular piece of foldable paper, just follow these simple steps.

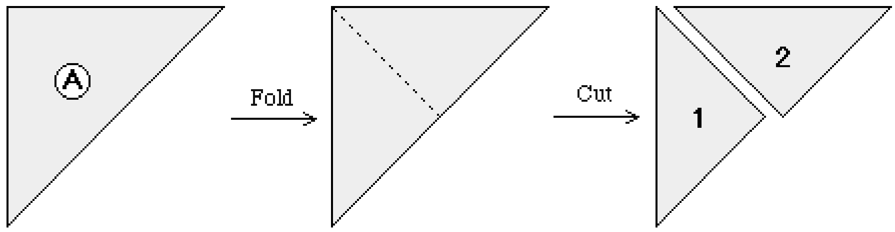
1) Fold a rectangular piece of paper to form a square. Cut off the extra flap.



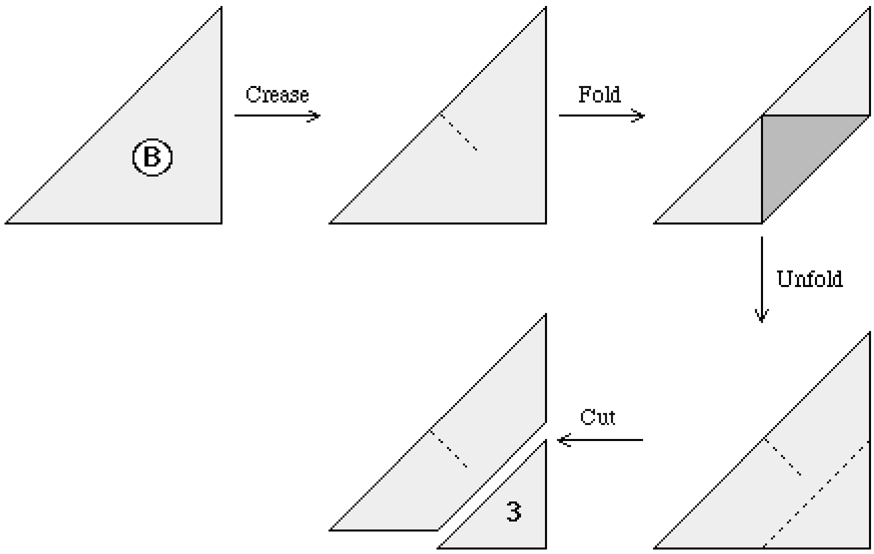
2) Cut the square into two triangles.



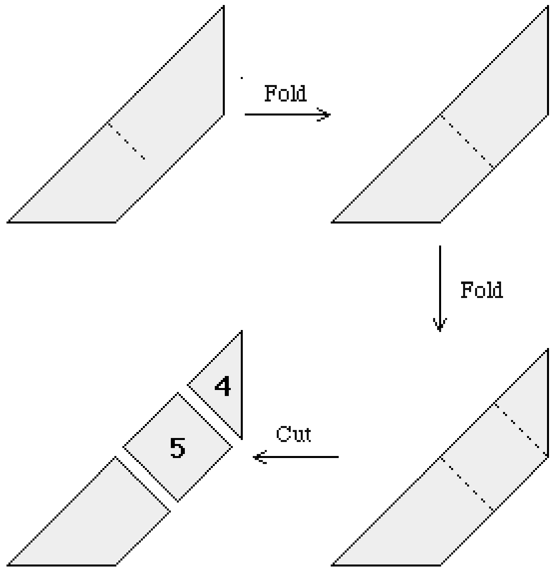
3) Take one triangle and fold it in half. Cut the triangle along the fold into two smaller triangles.



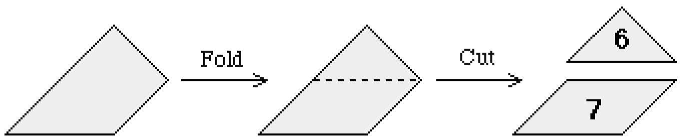
4) Take the other triangle and crease it in the middle. Fold the corner of the triangle opposite the crease and cut.



5) Fold the trapezoid in half and fold again. Cut along both folds.



6) Fold the remaining small trapezoid and cut it in two.



Activities Using Tangram

1) Areas of Tangram Pieces

Objectives

- ✓ a basic understanding of area without formulas
- ✓ a familiarity with the names of certain polygons(e.g., square, triangle, and parallelogram)
- ✓ the meaning of the term *congruent*
- ✓ to develop geometric intuition

Materials

- ✓ a package of tangrams (seven pieces) for each student (if tangrams are not available, students may construct their own)
- ✓ a student notebook (to record observations)
- ✓ a sharp pencil (for tracing geometric figures)
- ✓ a ruler
- ✓ an overhead projector (to illustrate geometric constructions)

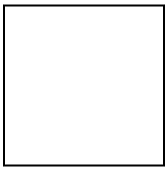
Warm-up activities

Have each student inventory his or her package of tangrams. Ask the question "What's in your package of tangrams?" Every student should have **seven tangram pieces,** including: a small square, two small congruent triangles, two large congruent triangles, a medium-size triangle, and a parallelogram.

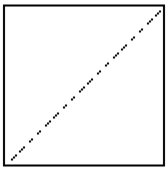
Primary activities

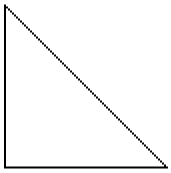
The goal of these activities is to determine the area of each tangram piece. These areas will be used to compute the areas of other polygons.

a) Trace the small square in a white blank paper. Let's suppose this square has area *one square unit*. Write "one square unit" under the small square.



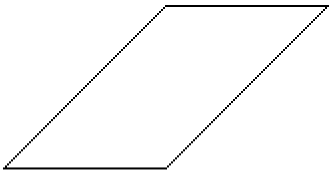
b) Make a square with the two small congruent triangles. What is the area of this square? How do you know?

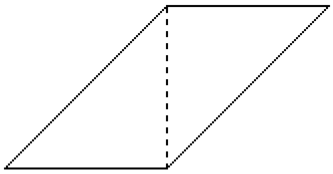




c) Trace one of the small triangles in the free space on the paper. What is the area of this triangle? How do you know? Write the area under the small triangle.

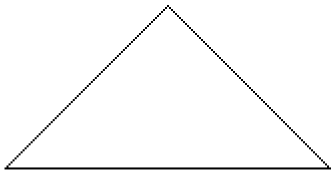
d) Trace the parallelogram in the free space on the paper or in another blank paper.

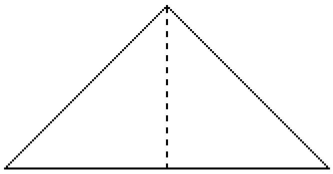




e) Make a (non-square) parallelogram with the two small congruent triangles. What is the area of this parallelogram? How do you know? Write the area under the parallelogram.

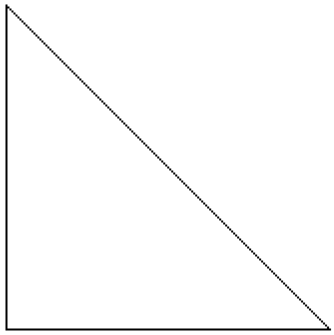
f) Trace the medium-size right triangle in the free space on the paper or in another blank paper.

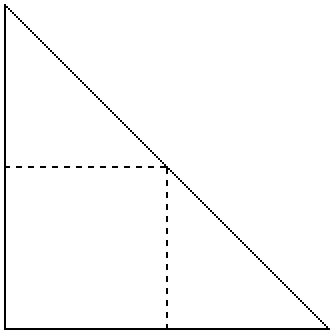




g) Make a triangle with the two small congruent triangles. What is the area of this triangle? How do you know? Write the area under the medium-size triangle.

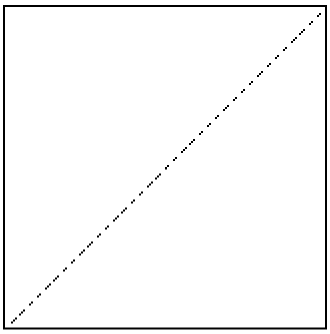
h) Trace one of the large triangles in the free space on the paper or in another blank paper.





i) Make a triangle with the small square and the two small congruent triangles. What is the area of this triangle? How do you know? Write the area under the large triangle.

j) Make a square with the two large congruent triangles. What is the area of this square? How do you know?



Repeat the primary activities assuming the small square has area two square units.

2) More Tangram Activities

Objectives

Students will have:

- ✓ a better understanding of area without formulas;
- ✓ the ability to compute the area of polygons by decomposition;
- ✓ a familiarity with the names of certain polygons (e.g., rectangle, trapezoid, and pentagon), the meaning of the term *similar;*
- ✓ to develop geometric intuition.

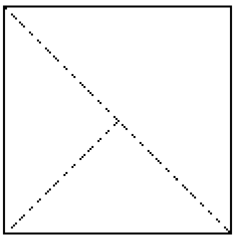
Materials

- ✓ a package of tangrams (seven pieces) for each student (if tangrams are not available, students may construct their own)
- ✓ a student notebook (to record observations)
- ✓ a sharp pencil (for tracing geometric figures)
- ✓ a ruler
- ✓ an overhead projector (to illustrate geometric constructions)

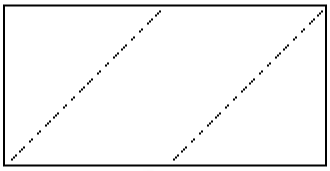
Primary activities

Knowing the area of each tangram piece from the previous activity, the student can compute the area of *any* polygon constructed from tangrams.

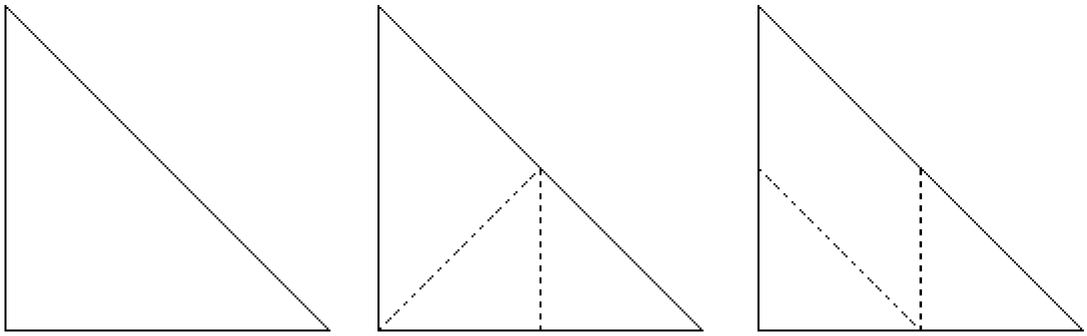
a) Make a square with the medium-size triangle and the two small congruent triangles. What is the area of this square? How do you know? Sketch the square in a white blank paper and record its area.



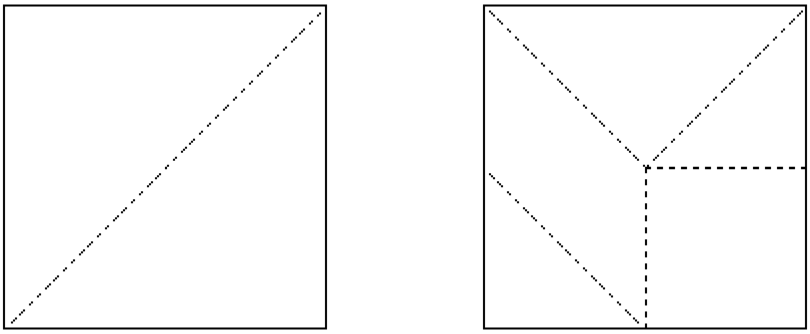
b) Make a rectangle with the parallelogram and the two small congruent triangles. What is the area of this rectangle? How do you know? Sketch the rectangle in a white blank paper and record its area.



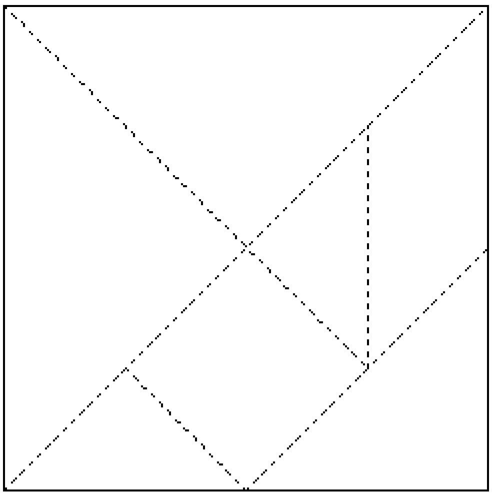
c) Construct a triangle congruent to the large triangle shown below *without using the small square*. Sketch the large triangle in a white blank paper and record its area.



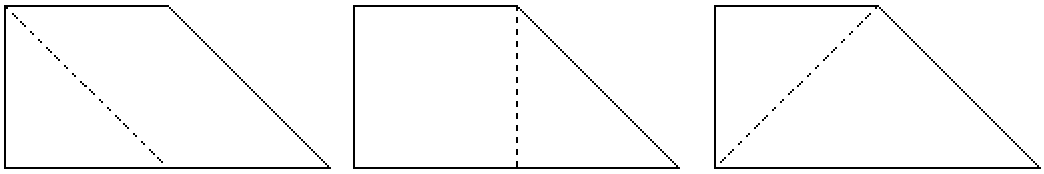
d) Make a square congruent to the square shown below *without using a large triangle*. Sketch the square in a white blank paper and record its area.



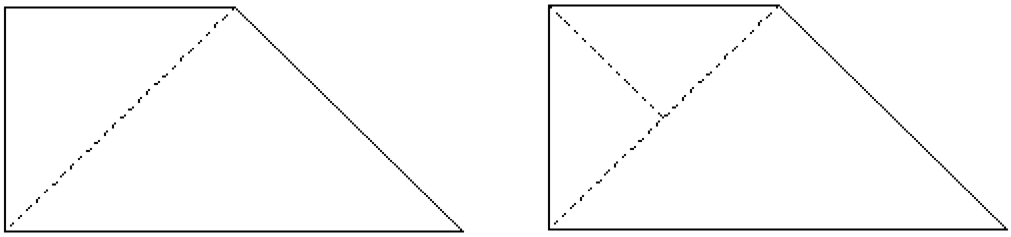
e) Construct a square using all seven tangram pieces. What is its area? How do you know? Sketch this large square in a white blank paper and record its area.



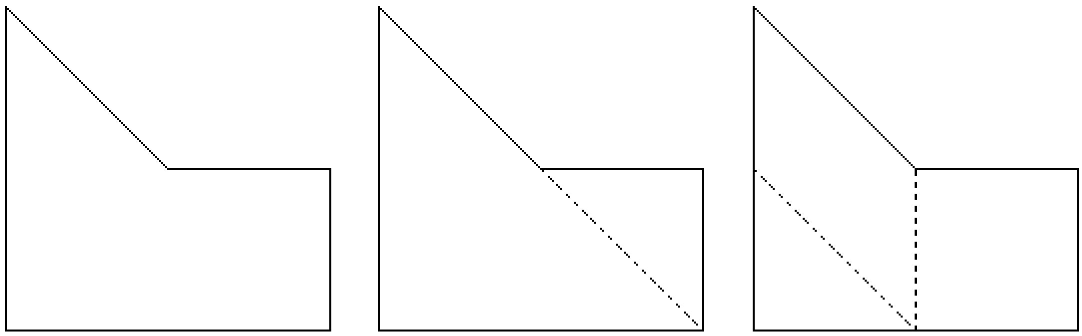
f) Find a trapezoid congruent to the trapezoid shown below. What is the area of this trapezoid? How do you know? Sketch the trapezoid in a white blank paper and record its area.



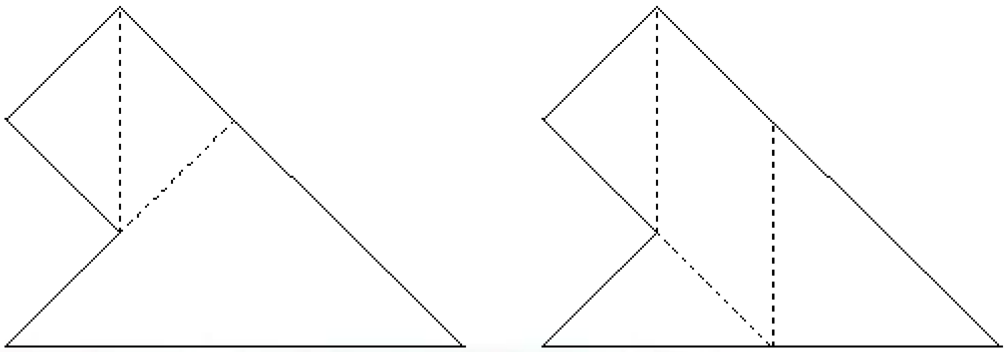
g) Find a trapezoid that is similar (but not congruent) to the trapezoid shown above. What is the area of this trapezoid? How do you know? Sketch the trapezoid in a white blank paper and record its area.



h) Find a pentagon congruent to the pentagon shown below. What is the area of this pentagon? How do you know? Sketch the pentagon in a white blank paper and record its area.



i) Find a pentagon congruent to the pentagon shown below *without using the small square.* What is the area of this pentagon? How do you know? Sketch the pentagon in a white blank paper and record its area.



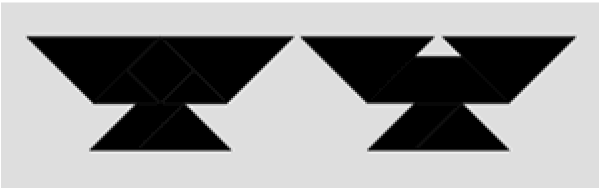
Extended activities

a) Suppose the square constructed in **activity e)** above has area one square unit. Determine the area of each tangram piece.

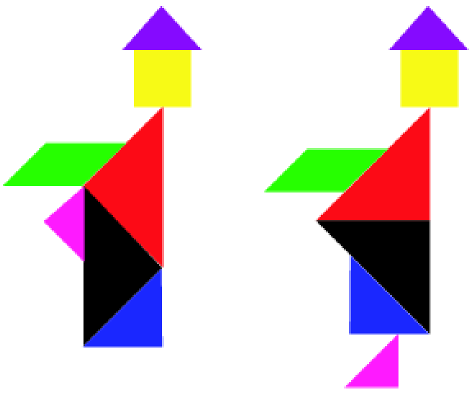
b) Repeat the previous problem assuming the large square has area twelve square units. Measure the *actual* area of each tangram piece.

Tangram Paradox

Look at the following two pictures of silhouettes of a bowl constructed from the same seven pieces of the tangram, before and after it was chipped.



Can you make the two bowls using the set of the same seven pieces of the tangram? Can you explain the paradox – why do they look different?



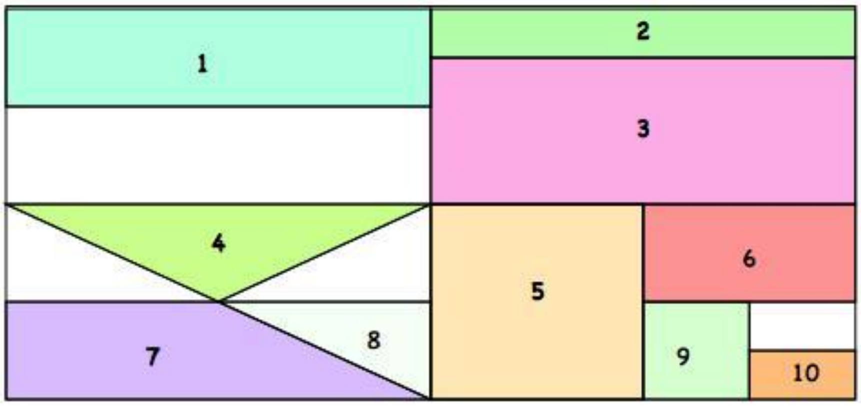
The Monk – Thesame set of tangram pieces can apparently produce two different figures, one of which is a proper subset of the other. This seems true only at a first glance: in reality the area is the same in both cases, since in the left picture the missing foot is compensated by a larger body.

1) If the puzzle costs $1, then how much is each piece worth? Write the value on the puzzle piece.

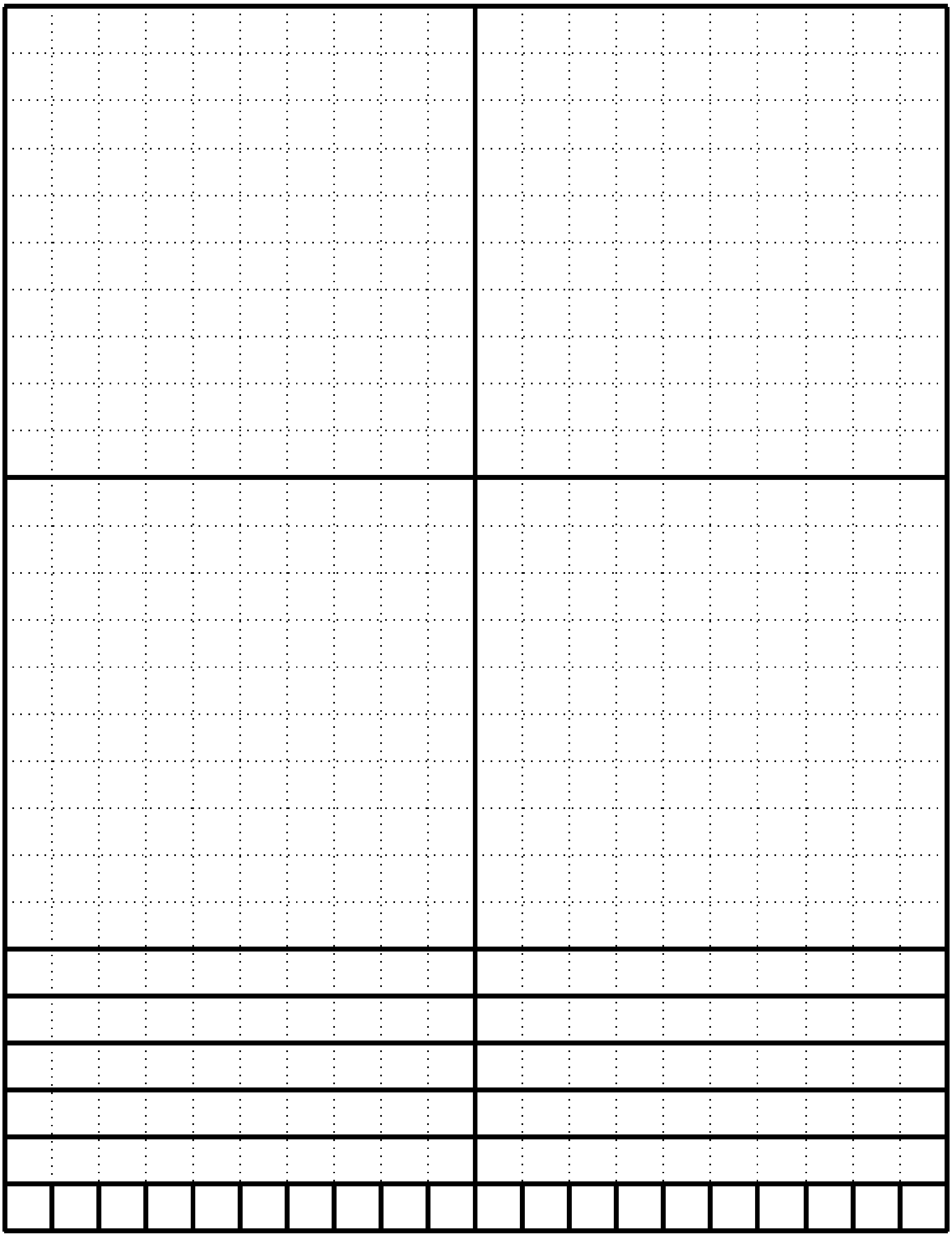
Large triangle	=	_______	= 0._________
Large triangle	=	_______	= 0._________
Medium triangle	=	_______	= 0._________
Small triangle	=	_______	= 0._________
Small triangle	=	_______	= 0._________
Square	=	_______	= 0._________
Parallelogram	=	_______	= 0._________
Total	=	_______	= 0._________

2) How do you know the money value? How do you change a fraction to a decimal?

D. Rectangular Blocks (Tiles)



- The Rectangular Blocks media/manipulative can be made from a thin-light wood, thick paper, foam, or transparent thick plastic.
- Cut/divide a large rectangular form material into a series of smaller quadrilaterals and triangles, as seen in the above design.
- Each shape represents a fractional part of the large rectangle. What fractional part is represented by each of the ten numbered shapes?
- The activities of using this media can be similar to those of using tangrams.



Base Ten Blocks

E. Base-Ten Blocks - Set of ones, tens, and hundreds.

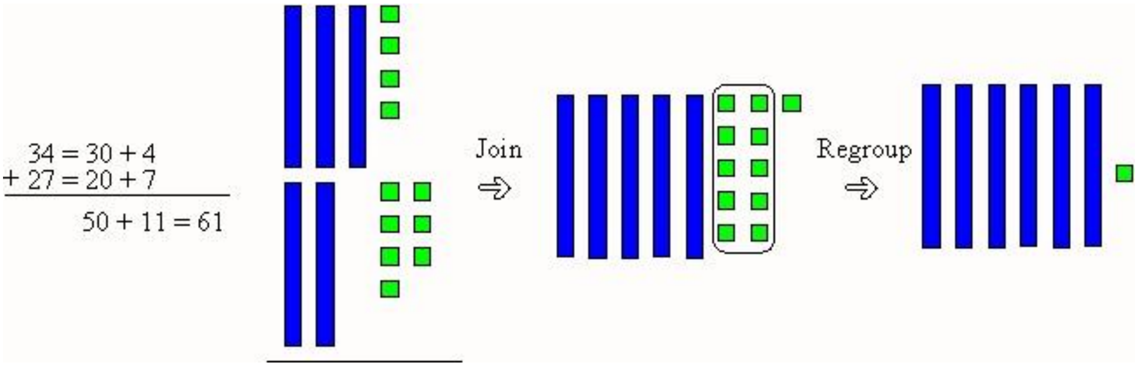
To make the base 10 blocks, copy the base 10 blocks design on a thin-light wood, thick paper, foam, or transparent thick plastic, and then cut along the solid lines. One set of base-ten blocks may consist of different numbers of hundreds, tens, and ones, depending on the numbers that will represent, or level of students.

Activities Using Base Ten Blocks to "See" Algorithms

Objective: To look at addition, subtraction, multiplication and division of whole numbers from a geometric, "hands-on" perspective, and an algorithmic perspective.

Addition

1. **One Type of Addition Algorithm**

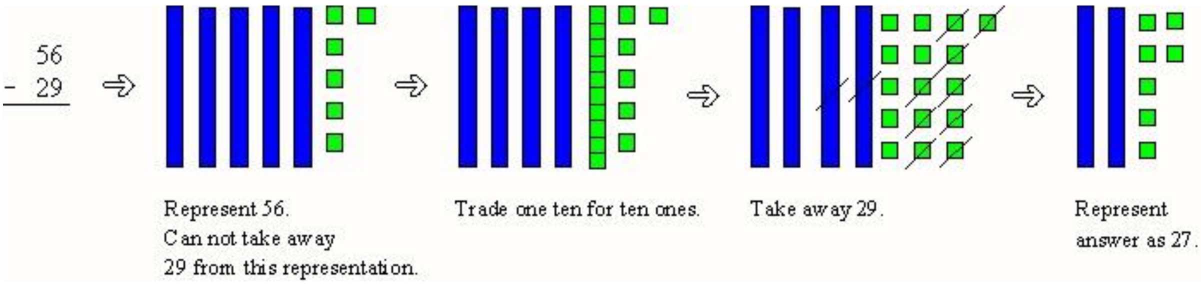


2. **Solve these problems using the base 10 blocks and the algorithm. Draw and write down the process.**

$$\begin{array}{r} 38 \\ +\ 13 \\ \hline \end{array} \qquad \begin{array}{r} 126 \\ +\ \ 45 \\ \hline \end{array}$$

Subtraction

1. **One Type of Subtraction Algorithm**



$$\begin{array}{r} 56 \\ -\ 29 \\ \hline \end{array} \Rightarrow \begin{array}{r} (50+6) \\ -(20+9) \\ \hline \end{array} \Rightarrow \begin{array}{r} (40+16) \\ -(20+\ \ 9) \\ \hline (20+\ \ 7) = 27 \end{array}$$

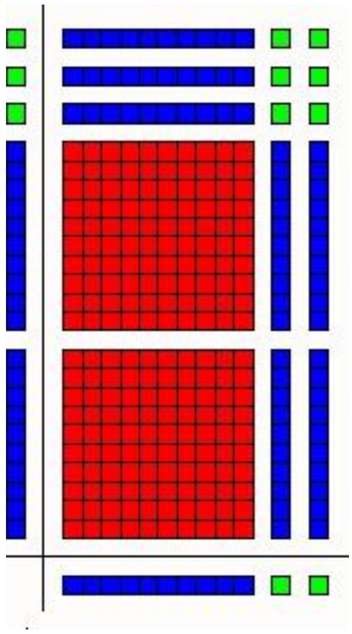
3. Solve these problems using the base 10 blocks and the algorithm. **Draw the model and write down the process.**

$$\begin{array}{r} 63 \\ -\ 25 \\ \hline \end{array} \quad \begin{array}{r} 50 \\ -\ 23 \\ \hline \end{array}$$

Multiplication

1. If there are 23 students and each of them needs 12 straws for a craft project, how many straws are needed to supply? This is written as 23 groups of 12 or 23 × 12. Write out how you would find the solution to this problem. The multiplication can be done in both vertical and horizontal formats. Compare the computations in vertical and horizontal formats with the real model using base-ten blocks.

   Vertical method:



$$
\begin{array}{rrrl}
 & 2 & 3 & \\
\times & 1 & 2 & \\
\hline
 & & 6 & = 2\text{x}3 \\
 & 4 & 0 & = 2\text{x}20 \\
 & 3 & 0 & = 10\text{x}3 \\
2 & 0 & 0 & = 10\text{x}20 \\
\hline
2 & 7 & 6 &
\end{array}
$$

   Horizontal method:

$$
\begin{aligned}
12 \times 23 &= (10 + 2) \times (20 + 3) \\
&= (10 \times 20) + (10 \times 3) + (2 \times 20) + (2 \times 3) \\
&= 200 + 30 + 40 + 6 \\
&= 276
\end{aligned}
$$

2. Solve the following problems using the base 10 blocks. Write down and draw multiplication model. Write out the details of the algorithm and find the products using the base-ten blocks model. Notice that the second problem is multi step. (Why?)

$$
\begin{array}{rrr}
 & 1 & 4 \\
\text{x} & 1 & 2 \\
\hline
\end{array}
\qquad\qquad
\begin{array}{rrr}
 & 2 & 4 \\
\text{x} & 1 & 3 \\
\hline
\end{array}
$$

Division

1. Suppose there are 483 sea shells for a class art project. Each student needs 21 shells. How many students will be able to make the project? How many groups of 21 shells can you form out of 483 objects? This can be written as 483 ÷ 21. Write out how to find the solution to this problem using the base-ten blocks.

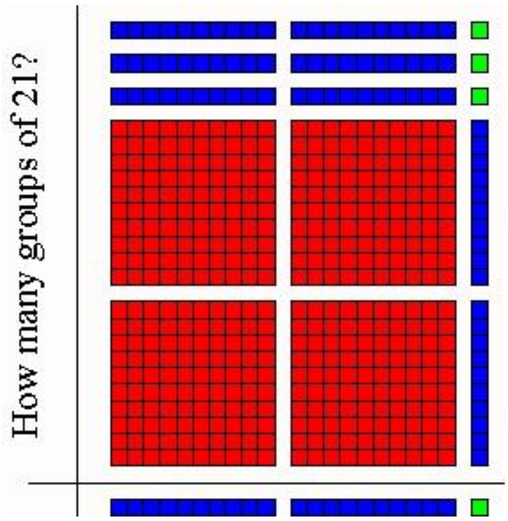
2. Find the numbers of groups of size 21 are on the Area Model. Draw in the left most columns with the appropriate "base 10 blocks."

3. Next, look at the **scaffold** method below. (Is there a correlation to the scaffold "good guess" method and the base-ten model? Does there have to be a relationship?)

4. Now, there are 483 sea shells for a class art project. There are 21 students in your class. If each student is given the same number of shells, how many shells will each student have? Use the blocks to model this problem. Is it still written 483 ÷ 21? Discuss.

   Scaffold:

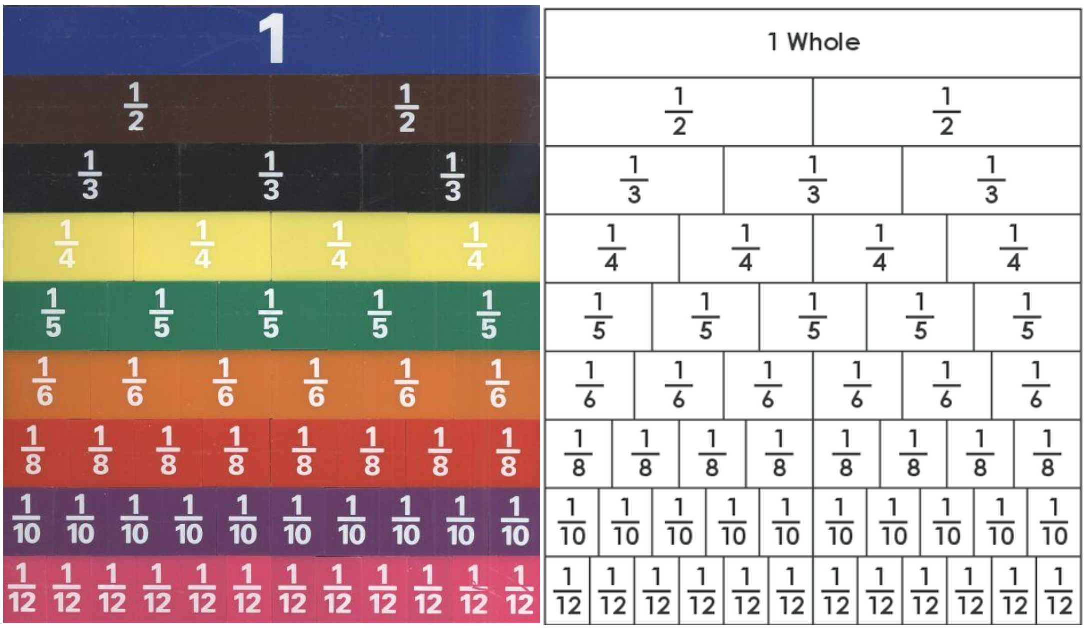
$21\overline{)483}$	
− 420	20 groups of 21
63	
− 63	+ 3 groups of 21
0	23 groups of 21



5. Solve these divisions by using base 10 blocks. Then, write out the solution as in the scaffold method.

$$13\overline{)299} \quad 14\overline{)308}$$

F. Fraction Tiles



Description

- Each tile has a color code and represents a whole (the number 1), or a fraction – either½, 1/3, ¼, 1/5, 1/6, 1/8, 1/10, or 1/12 (different fraction is different color).
- Each fraction has the same height with the others and has proportional length according to the fraction it represents(different fraction is different length, but is proportional).
- One set of fraction tiles consists of 51 tiles, composing from:
  - 1 tile of a whole (number 1),
  - 2 tiles of ½,
  - 3 tiles of 1/3,
  - 4 tiles of ¼,
  - 5 tiles of 1/5,
  - 6 tiles of 1/6,
  - 8 tiles of 1/8,
  - 10 tiles of 1/10, and
  - 12 tiles of 1/12.
- The fraction tiles can be made from wood, thick paper, mica, or thick plastic. Cut along the lines as seen in the design to get the tiles.
- The set can be made with the sizes that can be fixed into a storage tray or a permanent bag.
- The tiles can be used to introduce fraction concepts, to visualize fractional relationships, to perform simple math operations with fractions, decimals and percentages. Students can manipulate parts of a whole to see how they relate to each other.

The following hands on explorations are some activities that students can do with fraction tiles sets.

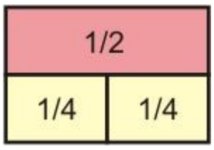
Fractional Parts

1. Ask students to use the fraction tiles to identify the tiles and talk about their relationships.
2. Count aloud with students each of the half tiles, the thirds, the fourths and so on, using fraction names.

After these activities students will become familiar with the fraction tiles and their relative sizes.

Comparing

Use the fraction tiles to compare the following fractions. Line up each fraction tile to see which fraction has the greatest length. Use >, <, or = to compare each pair of fractions. For example, when comparing 1/2 and 2/4, the fractions should be modeled and lined up as follows.



1. $\frac{3}{4}$ … $\frac{2}{3}$
2. $\frac{6}{8}$ … $\frac{5}{6}$
3. $\frac{2}{3}$ … $\frac{3}{6}$
4. $\frac{4}{8}$ … $\frac{1}{2}$
5. $\frac{7}{8}$ … $\frac{5}{6}$
6. $\frac{1}{4}$ … $\frac{2}{6}$
7. $\frac{4}{6}$ … $\frac{2}{3}$
8. $\frac{3}{8}$ … $\frac{4}{6}$

Use the fraction tiles to order the following fractions from the least to greatest.

9. $\frac{4}{6}, \frac{3}{8}, \frac{1}{2}$
10. $\frac{4}{8}, \frac{2}{3}, \frac{3}{4}$
11. $\frac{7}{8}, \frac{5}{6}, \frac{2}{3}$
12. $\frac{3}{4}, \frac{5}{8}, \frac{4}{6}$
13. $\frac{6}{8}, \frac{3}{4}, \frac{1}{2}$
14. $\frac{3}{8}, \frac{2}{4}, \frac{2}{3}$
15. $\frac{4}{8}, \frac{3}{4}, \frac{4}{6}$

Equivalent Fractions

Ask students to place a combination of two tiles on a line, and combination of other tiles on the second line (under the first line), the third line (under the second line), and so on, that have the same length. Ask students to draw the tile combinations on a grid paper and write the equivalent fractions, as the following example.

<table>
<tr><td colspan="4">$\frac{1}{3}$</td><td colspan="4">$\frac{1}{3}$</td></tr>
<tr><td colspan="2">$\frac{1}{6}$</td><td colspan="2">$\frac{1}{6}$</td><td colspan="2">$\frac{1}{6}$</td><td colspan="2">$\frac{1}{6}$</td></tr>
<tr><td>$\frac{1}{12}$</td><td>$\frac{1}{12}$</td><td>$\frac{1}{12}$</td><td>$\frac{1}{12}$</td><td>$\frac{1}{12}$</td><td>$\frac{1}{12}$</td><td>$\frac{1}{12}$</td><td>$\frac{1}{12}$</td></tr>
</table>

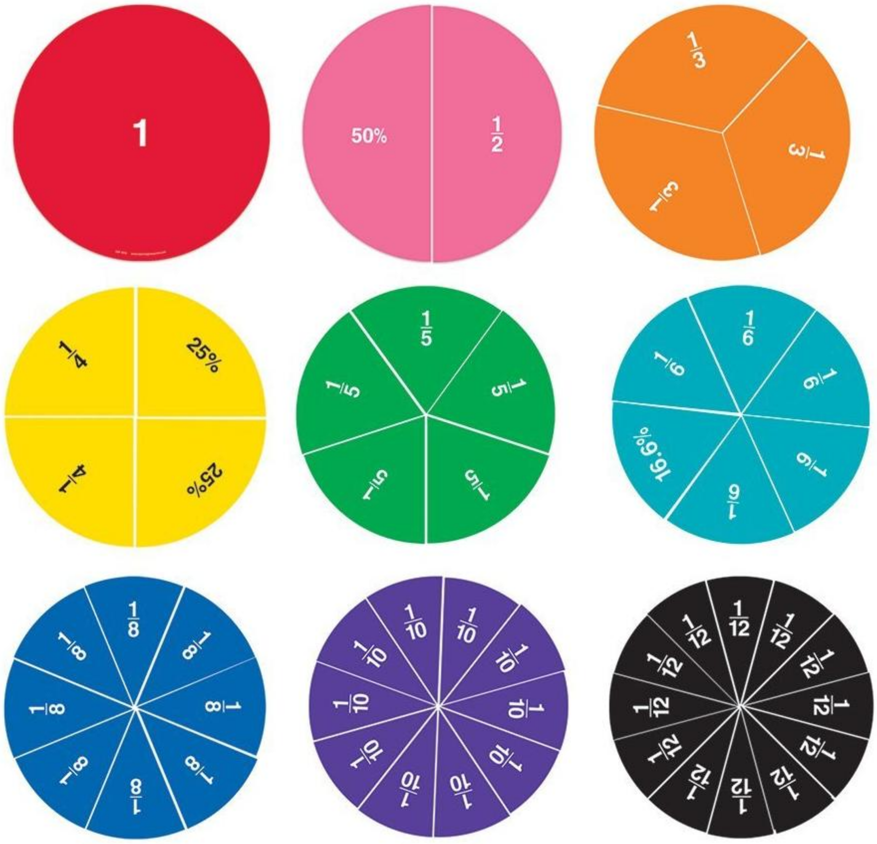
$$\frac{2}{3} = \frac{4}{6} = \frac{8}{12}, \quad \frac{1}{3} = \frac{2}{6} = \frac{4}{12}, \quad \frac{1}{6} = \frac{2}{12}$$

Greatest Fraction Game

Prepare an eight fraction cards set consisting of 1/4, 1/3, 1/2, 2/6, 3/4, 2/3, 7/8, and 4/12 cards and display all fraction tiles on a table. Choose two players and take a sheet of white paper and create a table with player names as labels its columns. Place all fraction cards face down in a pile.

Ask a player to choose a fraction card, and then take fraction tile(s) that have the same value as the fraction shown in the card. Ask the second player to do the same, and then compare their results. The player that chooses the largest fraction part wins both fraction tiles. The first player to make one whole with his/her fraction tiles scores a point and records it on his/her column. All fractional parts are then returned and play begins again. Continue the game until one player scores five points.

G. Fraction Circles with Percent Tag



Description

- Fraction circles are a set of nine circles of various colors.
- One circle is a whole. The other eight are divided into sectors represents a fraction:
  - one circle is divided into 2 same sectors, each represents ½,
  - one circle is divided into 3 same sectors, each represents 1/3,
  - one circle is divided into 4 same sectors, each represents ¼,
  - one circle is divided into 5 same sectors, each represents 1/5,
  - one circle is divided into 6 same sectors, each represents 1/6,
  - one circle is divided into 8 same sectors, each represents 1/8,
  - one circle is divided into 10 same sectors, each represents 1/10, and
  - one circle is divided into 12 same sectors, each represents 1/12.
- Each fraction has different color (different fraction is different color), as seen in the picture.
- One set of fraction circle consists of 51 pieces, each attachable to whiteboard.
- The fraction circle can be made from thin-lightwood, thick paper, foam, or thick plastic.
- The set can be put in a storage bag.
- The tiles can be used to introduce fraction concepts, to perform simple math operations with fractions, decimals and percentages. Students can manipulate parts of a whole to see how they relate to each other.

Sample Activities

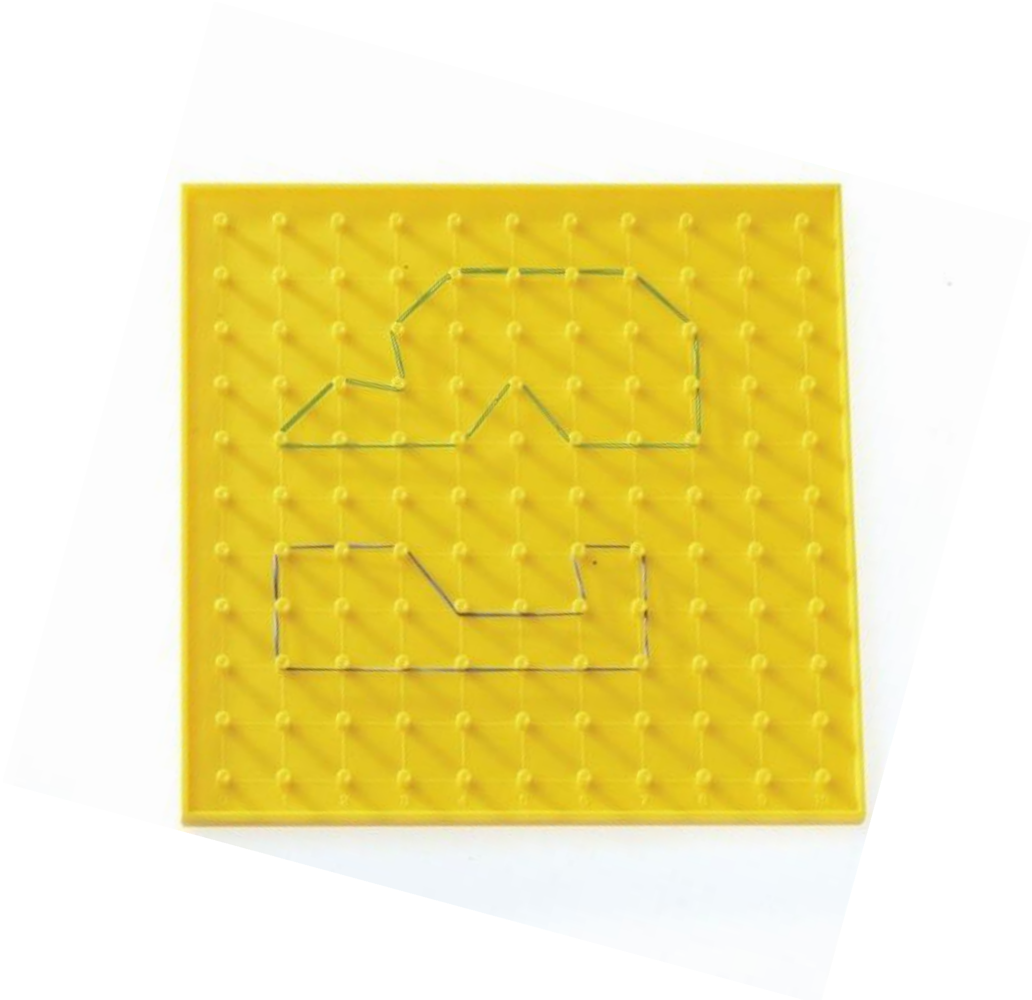
1. Have students orally count the ‘black’ pieces to create a whole. Have someone else count the ‘blue’ pieces after that. This allows students to practice saying the names of the parts that make up the whole.
2. Pairs discuss what it means to compare a circle divided into more parts with one divided into a lesser number of parts.
3. Which is larger 4/8 or 3/4? How do you know?
4. Compare and order ½, 2/3, 1/8, 3/5.
5. How many different ways can you make a half? A quarter? A third? One and one sixth?
6. Is there another fractional part(s) that can cover 9/12?
7. Add 1/2 + 1/3. Are there other equal fractional parts that can fit on top of what was created?
8. If you add 2/4 and 1/5 , how much of the circle is not completed?
9. Show 25%, 33%, 50%, 75%, 70% with the fraction circles.
10. Which fractional parts can be combined to equal 1/2?
11. Solve this problem, using fraction circles: team A won 1/3 of their soccer games this season. Team B won 25% of their soccer games. Which team won more games?
12. How many tenths are in 3/5? Or what is 3/5 ÷ 1/10?
13. Show 3 × 1/8 by joining fractional pieces. Try 3 × 2/8. What do you notice?
14. Show ½ × ¾ (Prompt students to first find an equivalent of ¾ so that it can be divided in half). Ask what students notice about the question and the answer.

Dividing Fractions with Fraction Circles

The division sign asks how many of the second fractions are in the first one. For example, 1/2 ÷ 1/4 asks how many fourths in a half, just like 10 ÷ 2 asks how many 2s in 10. Think of a rule to work the starred problems without Fraction Circles.

H. Geoboard 11 x 11 Pin

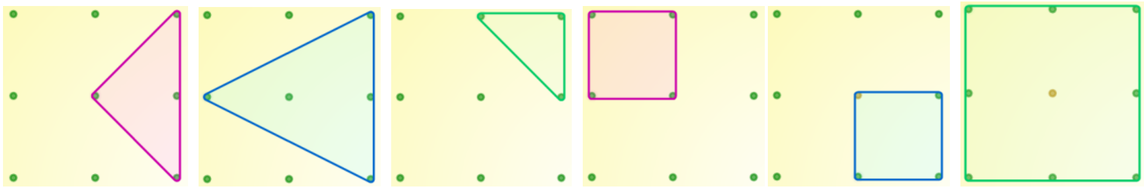
- This geoboard can be made from a square-form wood or other material of size 10".
- Use umbrella-head pins to make array of 11x11 pins arranged in order to keep rubber bands in place as students create designs, as shown in examples on the picture.
- Square-form pin array enable student to explore geometric concepts using rubber bands, including shapes, symmetry, congruency, area, perimeter, coordinates and spatial relationships.
- Geoboard complemented with rubber bands are excellent resources for helping children develop their concepts of shape and space in a practical way.

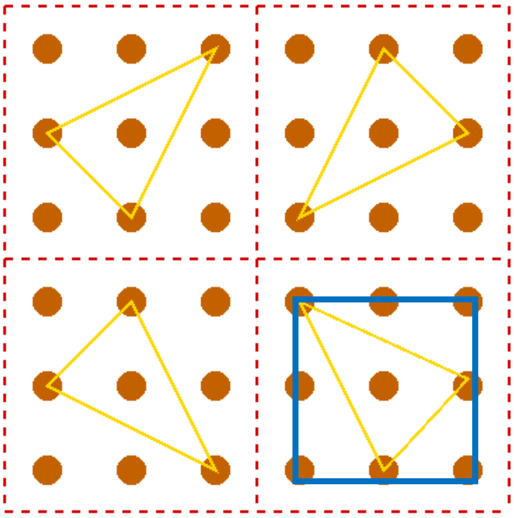


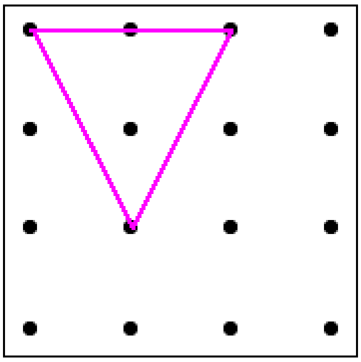
Example activity and exploration using Geoboard: inside Triangles

1) Using 3x3 pin arrays and a rubber band, how many different triangles can be formed? How do you know that you have found them all?
2) Using 3x3 pin arrays and a rubber band, how many different triangles with one pin in the middle can be formed? How do you know that you have found them all?
3) Using 3x3 pin arrays and a rubber band, how many different squares can be formed? How do you know that you have found them all?
4) Using 3x3 pin arrays and a rubber band, how many different squares with one pin in the middle can be formed? How do you know that you have found them all?
5) Using 4x4 pin arrays and a rubber band, how many different triangles can be formed? How do you know that you have found them all?
6) Using 4x4 pin arrays and a rubber band, how many different triangles with one pin in the middle can be formed? How do you know that you have found them all?
7) Using 4x4 pin arrays and a rubber band, how many different squares with one pin in the middle can be formed? How do you know that you have found them all?
8) Using 4x4 pin arrays and a rubber band, how many different squares with one pin in the middle can be formed? How do you know that you have found them all?

Similar questions (activities), with different sizes of array, can be asked to students.







For high level grades, the geoboard can be used to do explorations on area of triangles and other polygons. For example, ask students to find the area of each triangle in the 3 by 3 grids above. They may imagine that the area of each triangle is the area of square (which is 2x2=4) subtracted by the total areas of the three "outside" triangles (1+1+1/2=2.5). So, the area of each triangle is 1.5 square units.

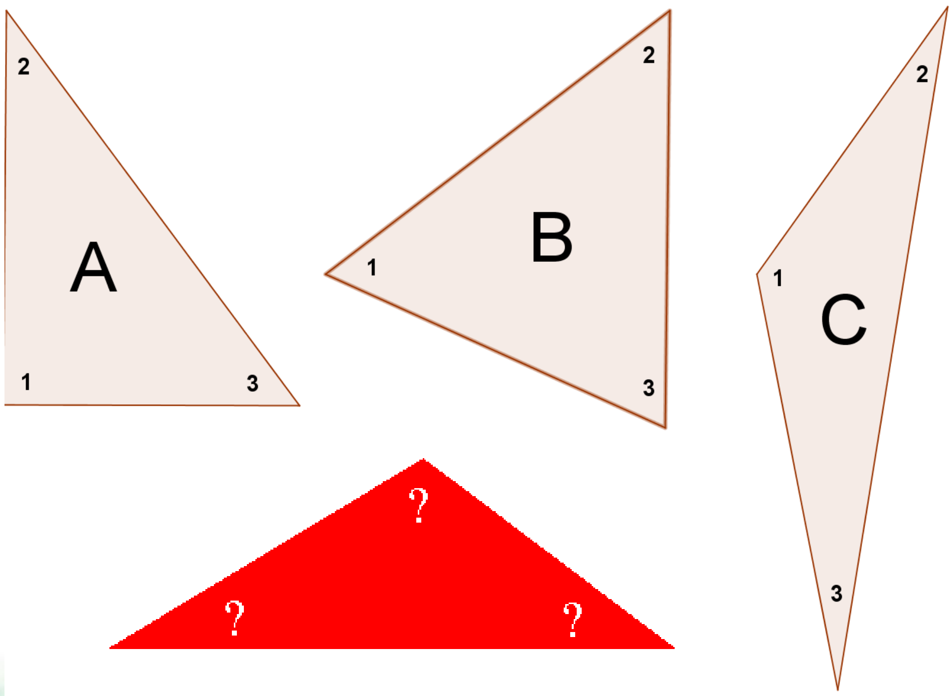
I. Number Cards and Counting Rods

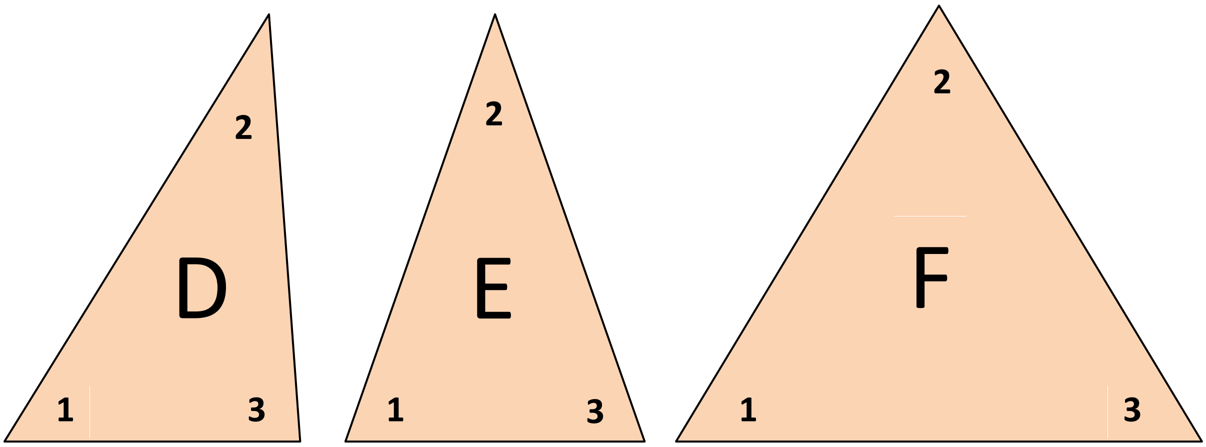
Description

- This media set can be made from wood.
- Each set consists of:
    - 52 counting rods (13 red rods, 13 blue rods, 13 green rods, and 13 yellow rods) – each is about 17 cm length,
    - 19 number cards (2 sets of numbers 0 to 8 and a number 9) in red color, and
    - 5 math signs (+, -, x, ÷,=) in red color.
- The size of number cards and math signs is 3 cm by 3 cm.
- It can be put in a wooden box or a transparent bag.
- It helps teach math skills and color recognition.

- It can cultivate children's ability in operating numbers (addition and subtraction, multiplication and division) and thinking. They learn (recognize and distinguish colors, count how many colors are there) and grow up in the process of playing wooden numbers.

J. Triangle Models





Triangle models can be created using thin-light wood, thick paper, foam, or thick plastic. Create models of right-angle triangle(A), acute triangle (B), obtuse triangle (C), scalene triangle (D), isosceles triangle(E), and equilateral triangle (F) with appropriate sizes. Names the angles of each triangle by 1, 2, and 3 as indicated in the examples.

Objective:

1) To investigate the sum of the measurement of the interior angles of a triangle using several methods.
2) To make a mathematical conjecture from observations.

Materials Needed:

1) Blank color paper and white paper
2) Protractor
3) Ruler
4) Scissors

Activities:

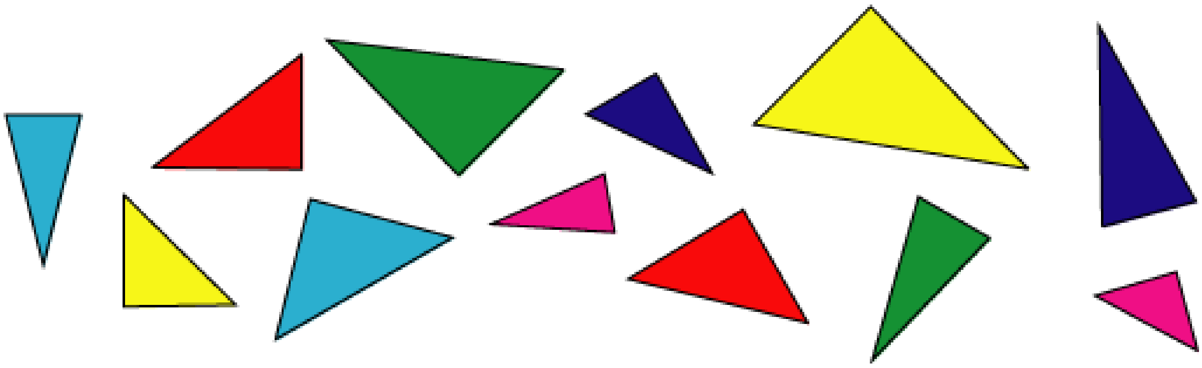
1) Copy the triangle models on a sheet of color paper and cut out one set of triangles. Tear these triangles into pieces.
2) Write a definition of a triangle.
3) Take triangle A and **rip off** the angles labeled 1, 2, and 3.
4) Make a line on a white paper and tape the angles along the line so that the angles have common sides.
5) Repeat number 4) for each other triangle.
6) What do you notice? Write a **conjecture** about the sum of the interior angles of a triangle.
7) Next, take a protractor and measure the interior angles of each triangle. Write the sum of the measurements and use mental math to add the angles together.

Triangle	Sum of interior angle	Triangle	Sum of interior angle
A		D	
B		E	
C		F	

8) What do you notice? What can you **conjecture**?

Do any of the above activities actually prove that the sum of the angles of a triangle is 180 degrees? Write a summary and a reaction to the different ways of exploring the angles of a triangle.

Another set of triangle models can be created using thick paper. The triangles are colored with different colors as seen in the following example. One set of triangle models may consists of 3 to 5 different families (each family has the same shape, but may have different size), and each family may consists of 2 to 4 different triangles of the same shape. Cut each triangle and the set of triangle models can be put in a transparent plastic bag.

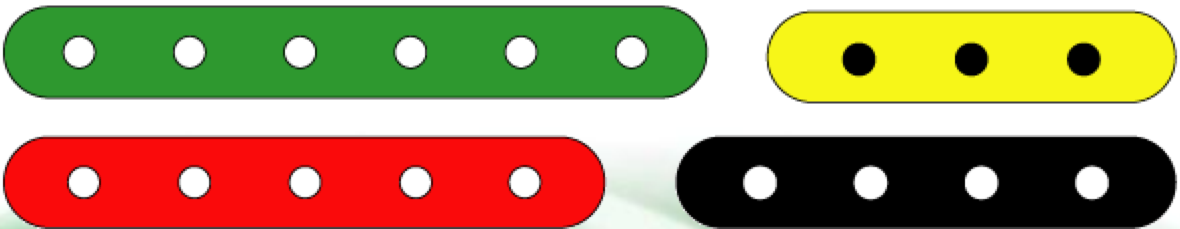


The activity for this media is asking students to sort the triangles and to explain their sorting.

K. Strips with Holes

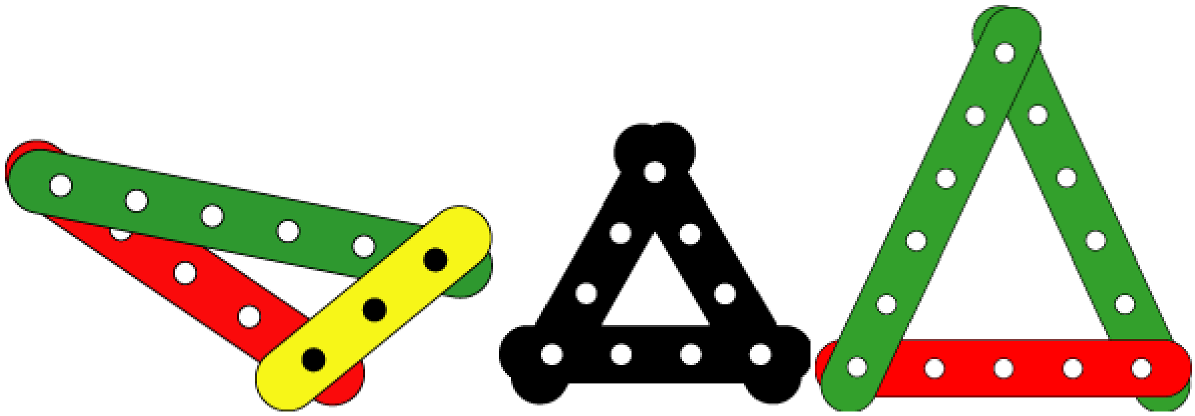
This kind of media can be created using thin and tight wood, mica, or thick paper. One set of strips consists of a number of strips with different lengths and colors. Each strip has holes to indicate its length. In the following example (but this is not the only possible set), in one set of strips there are:

- **oneyellow** strips with 3 holes
- **oneblack** strips with 4 holes,
- **onered** strips with 5 holes and
- **onegreen** strips with 6 holes.



Using these strips, students can be asked to investigate the properties of triangle. The following are some questions that may be asked to students.

1. Using 3 different length of strips, can you always construct a triangle?
2. Using 4 strips at most, how many triangles can you construct?
3. Using 5 strips at most, how many triangles can you construct?



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