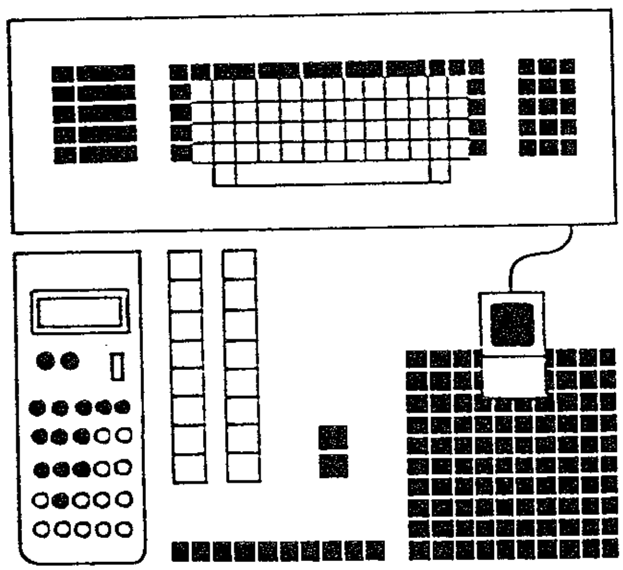
TEXAS MATHEMATICS TEACHER



Maps in the Mathematics Classroom

Squares of Consecutive Integers: Extensions to a Problem

Developing Problem Solving Skills Through the Use of Real Money

JANUARY 1988

TEXAS MATHEMATICS TEACHER, the official journal of the Texas Council of Teachers of Mathematics, is published four times each year, in October, January, March, and May. All manuscripts and editorial correspondence should be addressed to George H. Willson, listed above.

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TEXAS MATHEMATICS TEACHER
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TEXAS MATHEMATICS TEACHER

TEXAS COUNCIL OF TEACHERS OF MATHEMATICS

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January 1988

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ANNOUNCEMENTS

President's Message

The Conference for the Advancement of Mathematics Teaching not in Austin? Unheard of! It's always been in Austin! Moving CAMT to the summer was a brave, innovative move that was a tremendous success even though it broke with very strong tradition. Tradition also has it that CAMT belongs to Austin. However, for the last two years we've overrun Palmer Auditorium and the Hyatt. Rooms were too small and there weren't enough of them.

Enter the scene - the brand new, latest state-of-the-art in convention centers, the George R. Brown Convention Center in Houston. On the very days that 1988 CAMT was scheduled, August 2 - 4, it was available. Not only was it available, but it is an incredible facility. There will be no rushing in August heat from building to building. All sessions, the exhibits, NCTM materials, Make-it-take-it, and registration will be not only in one building, but on one floor of that building! You're going to LOVE it!

Congratulations to Cathy Peavler and the CAMT Executive Committee for being responsive to the pleas for more room issued by those who attend. The CAMT Executive Committee, if you didn't know, is made up of representatives from TCTM, TEA, TASM (Texas Association of Supervisors fo Mathematics) and UT Austin.

1988 CAMT will be August 2 - 4 at the George R. Brown Convention Center, Houston, Texas. Texas mathematics teachers rush in where Democrats fear to tread!

The date change from school days in the fall to vacation time during August was an enormous success. The 1988 move to a beautiful, large new facility will be a greater success, for there will be room for even more of us to attend! Let's!

Maggie Dement

Maps in the Mathematics Classroom

Charles D. Reinauer

Jan Jacinto College
Pasadena, Texas

The use of maps in a mathematics classroom can (1) provide weeks of substantial mathematics activities, (2) serve as a source of motivation for learning, and (3) be a meaningful and useful experience in the education of students.

There are many types of maps available for classroom use. Road and city street maps are easily obtained and are full of applications of arithmetic, algebra, and geometry. Activities can range from planning a trip across Texas to some of the fascinating results in Taxicab Geometry. The use of globes can lead to discussions in solid, projective, and non-Euclidean geometries, as well as trigonometry, and solid analytic geometry. Contour maps can be excellent sources for developing the idea of slope, and the representation of three-dimensional situations in two dimensions. Nautical, aeronautical, demographic, and other specialized maps reinforce the need for map-reading skills in the real world, and supply exciting examples of applications of basic mathematics.

The motivational factor is important. There is a natural fascination and inquisitiveness about maps, if for no other reason than to locate oneself, and this can be capitalized on as an introduction. Motivation must be sustained, and this can be done when the source of motivation is, as Bruner would say, intrinsic. The instructional climate of both school and classroom play a large role in sustaining motivation. Maps can be a source of interest which aid a proper learning climate.

Experience, according to Dewey, is one of the best sources of learning. Many youngsters have had some experience with maps, most probably road maps. Such experience can be used as the basis for a more systematic development of map reading, map making, and many mathematical skills. Experiences with maps have the added benefit of being activity-oriented as well as practical. They also fit into some interdisciplinary projects involving social studies and science.

What follows is an outline of some topics, projects, resources, and references for several types of maps. Some examples of activities have also been included.

ROAD MAPS

1. Topics

   a. Highway designations
   b. Legends
   c. Population centers
   d. Cardinal directions
   e. Map grids
   f. City map inserts
   g. Distance tables
   h. Distance between markers

2. Projects

   a. Most efficient routes
   b. Planning a trip across Texas
   c. Rapid transit
   d. Locating a service depot
   e. Trucking and deliveries
   f. Traveling salesman problem

3. Resources

    a. State Department of Highways
    b. AAA
    c. UPS, trucking companies
    d. Driver education classes
    e. Oil companies
    f. Travel agencies

4. References

    a. Allison, W. M. "Gas Station Map Mathematics," Arithmetic Teacher, May, 1973.
    b. Dede, R. "Mapping with Math," Instructor, November, 1979.
    c. Jacobson, H. R. "Ecology, Rapid Transit and Graph Theory," Arithmetic Teacher, April, 1974.
    d. Kennedy, J. "The Traveling Salesman Problem," Mathematics Teacher, November, 1972.

5. Sample Activity

    a. A trip from Houston to Texarkana is approximately _____ miles. The estimated time for travel is _____ hours. The average speed required to make the trip in the estimated time is ___ miles per hour.
    b. In traveling from Marshall to Shreveport, are you mostly heading east or north? Can we be more precise? What about going from Shreveport to Marshall?
    c. It is approximately 68 miles from Houston to Livingston on US 59. It is approximately 190 miles from Houston to Carthage on US 59. Approximately how far is it from Livingston to Carthage on US 59? ___
    d. It is almost 70 miles from Houston to Huntsville, and 68 miles from Houston to Livingston. Should it not be only 2 miles from Huntsville to Livingston? ___ Why?

e. Which is the shortest route from Palestine to Lufkin?

Route A: US 84 to Rusk, US 69 to Lufkin

Route B: US 287 to Crockett, Texas, 7 to Ratcliff, TX 103 to Lufkin

Route C: US 287 to Elkhart, Texas, 294 to Alto, US 69 to Lufkin

STREET MAPS

1. Topics

   a. Local orientation
   b. Coordinates
   c. Distance formulas
   d. Taxicab Geometry

2. Projects

   a. Traffic flow
   b. Delivery services
   c. City planning
   d. Routing around obstructions

3. Resources

   a. City Planning Department
   b. Police Department
   c. Transit authority
   d. Civil Defence
   e. Taxi companies

4. References

a. Krause, E. "Taxicab Geometry," Mathematics Teacher, December, 1973.
b. Lepowsky, W. "Path Tracing and Vote Counting," Mathematics Teacher, January, 1976.
c. Smith, S. "Taxi Distance," Mathematics Teacher, May, 1977.
d. Willcutt, R. "Paths on a Grid," Mathematics Teacher, April, 1973.

5. Sample activity

   a. Taxicab Geometry was developed by Eugene F. Krause (1973) using the basic axioms of Euclidean geometry, substituting a new distance formula for the usual Pythagorean distance. To go from point A to B under the new distance formula, the taxi must follow the streets and turn the corners. Some very interesting results are obtained.
   b. Select two points on a grid and label them A and B.

      1. How many different routes (paths) are there from A to B?
      2. Generalize to the number of paths from the origin to A.
      3. Describe the points which are equidistant from A and B.

GLOBE

1. Topics

   a. Geometry on the sphere
   b. Longitude and latitude
   c. Geodesic paths
   d. Cartography

2. Projects

   a. Mercator projections
   b. Early Spanish maps of Texas
   c. Circumference of Earth

3. Resources

   a. NASA
   b. Publishers

4. References

   a. Abbot, E. Flatland, 1952.
   b. Fischer, I. "The Shape and Size of the Earth," Mathematics Teacher, May, 1967.
   c. Kline, M. Mathematics in Western Culture, Dover, 1953.
   d. Shilgalis, T. W. "Maps: Geometry in Geography," Mathematics Teacher, May, 1977.
   e. Vergara, W. Mathematics in Everyday Things, Signet, 1959.
   f. Whitman & Okita. "Constructing an Inexpensive Sphere," Arithmetic Teacher, April, 1964.

NAUTICAL AND AERONAUTICAL MAPS

1. Topics

   a. Air speed vs. ground speed
   b. Flight miles vs. road miles
   c. Rotation of the earth
   d. Nautical vs. land miles

2. Resources

   a. U.S. Coast Guard
   b. U.S. Navy
   c. Merchant Marine
   d. NOAA
   e. Commercial airlines
   f. FAA

WEATHER MAPS

1. Topics

   a. Data collection
   b. Local weather patterns
   c. Probability
   d. Use of contours

2. Resources

   a. U.S. Weather Bureau
   b. Local TV stations

TOPOGRAPHIC MATS

1. Topics

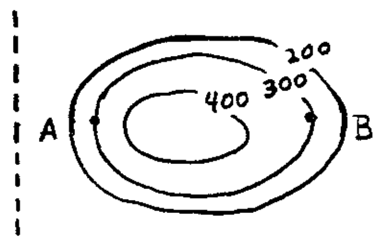
   a. Euclidean distance
   b. Slope
   c. Representation of height on two dimensional maps

2. Resources

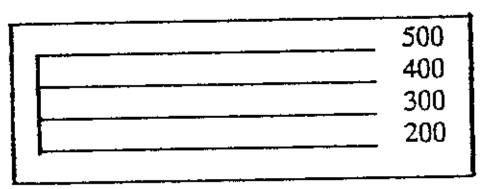
   a. U.S. Department of Interior
   b. Army Corps of Engineers
   c. U.S. Government Printing Office
   d. NASA

3. Sample Activity

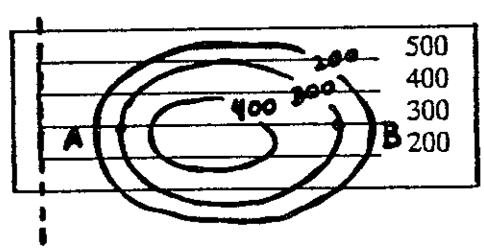
   a. Contour maps represent a technique for showing a three dimensional situation in a two-dimensional display. Given a location in two dimensions, a third variable might represent elevation, temperature, or pressure at that point. The curves which join all points of equal value on the map are called level curves, or contours. Topographic maps show the shape of the land by contour lines which join all points of equal elevation. Weather maps show all points of equal temperature or equal pressure at a given time on a given day.
   b. Given a small portion of a topographic map, questions about run, rise, and slope can be asked. It is also possible to construct the silhouette of the land in any vertical plane passing through any two points on the land.



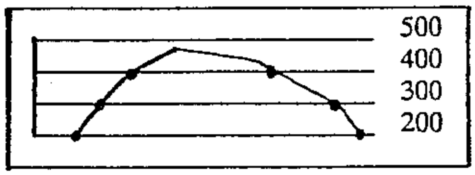
This can be done by using a transparency on which parallel lines are labeled with the elevations in the appropriate increments.



Lay the transparency over the map and mark the intersections of each contour line with a corresponding elevation line on the transparency.



A silhouette can be made by joining the points and estimating a peak.



CENSUS AND RESOURCE MAPS

1. Topics

   a. Population density
   b. Best location for . . .
   c. Information gathering for word problems

2. Resources

   a. Texas State Atlas
   b. Texas Department of Highways
   c. Public libraries

The American Automobile Association is cooperative in providing materials, such as maps, or Triptik inserts, which are small and easy to handle. In addition, the U.S. Department of Commerce, through the National Oceanic and Atmospheric Administration (NOAA), publishes two pamphlets:

1. "List of Free and Inexpensive Educational Materials"
2. "A Guide to Books on Maps and Mapping"

which are available free by writing to NOAA, National Ocean Survey, Rockville, Maryland 20852.

Squares of Consecutive Integers: Extensions to a Problem

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An interesting aspect of solving any problem is the possibility that extensions may occur. At the secondary level new proofs are often the by-product of numerical investigations. One such proof resulted from a group of students considering the following problem, which was to be solved orally by teams. No writing or calculators were permitted.

> "a^2, b^2, and c^2 are squares of consecutive integers (e.g.: 4, 5 and 6 could yield 16, 25, 36). If a^2 = 17,689 and c^2 = 18,225, then b^2 =
>
> a) 17,991 b) 18,022 c) 18,024 d) 17,956 e) 17,904"

The students quickly reasoned that c had to have 5 in its ones place since its square ended in 25. Then b had to have a 4 in its ones place. Squaring 4 makes 16, which puts a 6 in the ones place of the squared number. This makes choice (d) the correct response.

Another approach used by the students was to focus first on the number a^2. Since it ended in 9, the number a had to have either 3 or 7 in its ones place. Then b had to end in 4 or 8. Since c had to end in 5, b had to have 4 in its ones place. (d) was again chosen as the answer.

During the oral solving of the problem, one student recalled a numerical property from earlier studies: "The sum of two consecutive integers equals the difference of their squares." The student could not remember a proof for the statement, but was convinced that it worked, demonstrating it with 16, 25, and 36 to fellow team members. The question then arose as to whether the property was limited only to consecutive positive integers.

After the "oral" problem had been solved, the students quickly picked up their pencils and began to try other number combinations in an effort to check their hypothesis. The following pairs were tested and a table prepared in order to look for any possible patterns:

Integers with a difference of 1:	3, 4 : 3 + 4 = 7 9, 16: 16 - 9 = 7	4, 5 : 4 + 5 = 9 16, 25: 25 - 16 = 9
Integers with a difference of 2:	3, 5 : 3 + 5 = 8 9, 25: 25 - 9 = 16	
Integers with a difference of 3:	3, 6 : 3 + 6 = 9 9, 36: 36 - 9 = 27	
Integers with a difference of 4:	3, 7 : 3 + 7 = 10 9, 49: 49 - 9 = 40	

A pattern soon became apparent between the sum of the two integers and the corresponding difference between their squares:

7 x 1 = 7, 9 x 1 = 9; 8 x 2 = 16; 9 x 3 = 27; and 10 x 4 = 40

The second factor in each product equaled the difference between the two integers used in each case.

The next task was to try to formally state the theorem to be proved. The following statement was considered:

"Let a and n be positive integers such that $b = a + n$.

If $a + b = k$, then $b^2 - a^2 = nk$."

Proof: For any positive integers a and n,

$$a + b = a + (a + n) = k.$$

Then $a + n = k - a$. Therefore,

$$\begin{aligned} b^2 - a^2 &= (a + n)^2 - a^2 = a^2 + 2an + n^2 - a^2 \\ &= 2an + n^2 = n(2a + n) = n[a + (a + n)] \\ &= n[a + (k - a)] = n(k) = nk. \end{aligned}$$

Conclusion: The integers a and b do not have to be consecutive integers.

Another question arises: Must the integers a and n be positive? Could either be 0? Consider the possibilities. 1) If both a and n are 0, then $b = 0$ and the equations in the proof become zeros; this knowledge contributes little to our understanding although the theorem still holds true. 2) If $a > 0$ and $n = 0$, then $b = a$, $a + b = 2a$, and $b^2 - a^2 = 0(2a) = 0$.

Sample pair: $a = 3$ and $b = 3$, $a + b = 6$ and $b^2 - a^2 = 0$ or $0 \times 6 = 0$.

3) If $a = 0$ and $n > 0$, then $b = n$, $a + b = n$, and $b^2 - a^2 = n(k) = n^2$.

Sample pair: $a = 0$ and $b = 5$, $a + b = 5$, and $b^2 - a^2 = 25$ or $5 \times 5 = 25$

Observation: The theorem holds for a and n as nonnegative integers.

Still a second question arises: Could a or n be a negative integer? Consider a = 3 and n = -5, so that b = -2. Does the theorem hold? Now try a = -5 and n = 4, so that b = -1. Does the theorem still hold true? What about a = -2, n = -3 and b = -5? Does this mean that the theorem holds for all integers a and n? For the answer, look at the original steps in the proof. In the equations and substitutions used, were any assumptions needed about the numerical values of a and n? If not, then a and n need only be integers, rather than nonnegative integers.

Other possible extensions: Could a or n be any rational number or any real number? These are left for the reader to consider.

Students should be encouraged to ask probing questions like the above to help them more fully understand the theorem they have just proved. Too often we write proofs in symbolic form and never give them any "skin" or reality for our students. They need to test different cases in order to convince themselves that the "logical reasoning" used in the steps of the proof is intuitively logical to them.

In conclusion, in order to improve instruction in problem solving, it is helpful for a teacher to perform a self-analysis now and then. For example, in the above discussion, were you disturbed that the theorem was never stated in its final "perfect" form? Rather, it was allowed to evolve, based upon students' investigations of the possibilities. Sometimes in our striving for mathematical rigor, we actually destroy the very reasoning and questioning we are trying to encourage in our students. There is a time for creating an atmosphere for problem solving and a time for demanding mathematical rigor, but the two moments do not necessarily coexist.

Developing Problem Solving Skills Through the Use of Real Money

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Many mathematics educators believe that the use of real objects is one of the keys to meaningful and motivating instruction. As early as the beginning of the 19th century, Pestalozzi held that the use of objects helped in developing arithmetic concepts (Suzzallo, 1911). Over one hundred years later, William Brownell reported utilizing (concrete) materials to provide arithmetic meaning (Brownell & Moser, 1949). The strength of these timeworn arguments for incorporating objects into the instructional process has gained considerable support the last twenty years. As testimony, the National Council of Teachers of Mathematics (NCTM) devoted the February 1986 issue of its journal, Arithmetic Teacher, to the topic of using manipulatives to teach mathematics ("Manipulatives," 1986).

In concert with this recent support to utilize concrete materials there has been an overwhelming concern to increase the problem solving skills of school children. The National Assessment of Educational Progress reports (1975, 1980, and 1983) point only too clearly that students' skills in solving problems are lacking. NCTM reacted strongly to the first NAEP report when it released its recommendations for school mathematics for the 1980's (NCTM, 1980). The number one concern was problem solving. Numerous articles, conference talks, and research topics focusing on problem solving followed.

To address the concerns of motivation and meaning, several activities are described below that encompass the effective use of materials (coins) within problem solving settings. It is strongly recommended that real money (vs. play) be used in each activity. Several reasons for using real money are offered:

1. it has been demonstrated to catch and hold children's attention better.

2. transfer to real world (outside of school) situations is easier.

3. cost for materials is less (students and teachers are less careful with play money and, therefore, "money" is lost and needs to be replaced).

Activities

This notation is used in activities A-D:

Q - quarter D - dime N - nickel P - one cent (penny)

Activity A. Coin drop
Mathematics skills: counting, addition, graphing
Level: Primary (grades 2 & 3)

Procedures:

Take a set of coins (e.g., 3 Qs, 4 Ds, 4 Ns, 6 Ps) and drop them on table or floor.

a. Separate into two subsets, heads and tails.

b. Find the value of each subset and tell (your partner) which is greater.

c. Repeat the above steps several more times and record results in a table (see Figure 1).

d. Circle the lesser amount of each trial in your table.

e. Graph results of four trials and compare your results to other students.

Figure 1: Recording results of coin drops

	Heads Value	Tails Value
Trial 1		
Trial 2		
Trial 3		
Trial 4		
Total		

Activity B. Making Specific Amounts Using Exactly 5 Coins
(amounts and number of coins are arbitrary)
Mathematics skills: counting, comparing, problem solving
Level: Primary (grades 2-4)

Procedures:

Using any <u>5 coins</u> from a set of 4 Qs, 4 Ds, 4 Ns, and 4 Ps, try to make these amounts (some may not be possible):

a. 46¢	d. 100¢
b. 13¢	e. 71¢
c. 39¢	F. 60¢

Activity C. Equivalent Amounts Using Different Coin Arrangements

Mathematics skills: recognizing equivalent amounts, estimation, measurement (mass), comparisons

Level: grades 3-5

Procedures:

Use a set of coins consisting of at least 4 Qs, 8 Ds, 16 Ns, and 70 Ps.

a. Show 42¢ two different ways using any of the coins you wish. Place coins in two separate piles.

________________	________________
Pile One	Pile Two

b. Predict which pile weighs more (has the greater mass). Circle your choice. Now use a two-pan balance to see which of the above "42¢s" has the greater mass. How was your prediction?

c. Show 42¢ in another way such that the mass is greater (or less) than the first two ways. Show that you have successfully done this by using the two-pan balance.

d. Can you make 42¢ using exactly 6 coins? If so, show it.

e. Using a chart and coins show as many ways as you can of making 42¢ (see Figure 2). Compare your chart with several other classmates.

f. Repeat this activity (a-e) for a different amount of money between 21¢ and 64¢.

g. Class discussion.

Figure 2: Chart for showing number of coins

25¢	10¢	5¢	1¢	Amount
1	1	1	2	42¢
	2	4	2	42
1		2	7	42
				- - -
				42

Activity D. Predicting and Comparing Amounts
Mathematics skills: problem solving, comparisons, counting money, predicting, probability, measurement (mass)
Level: Grades 2-4

Procedures:

Use an arbitrary set of coins (say, 4 Qs, 4 Ds, 4 Ns, and 4 Ps).

a. Predict the following <u>prior</u> to dropping the set of coins.

1. Number of heads/tails.
2. Which set will have the least value, heads or tails?
3. Which set will weigh more, head or tails?

b. Record predictions on paper.

c. Shake coins in a container and drop on table or floor.

d. Separate into two sets of heads/tails.

e. Check each of your predictions.

f. Compare results with classmates on predicting, greatest/least number of heads/tails, greatest/least amount of money for each category, and greatest/least weight.

g. Make graphs to show results of step f.

Commentary to Teachers

The essence of these activities lies in allowing children to operate in a hands-on atmosphere (Williams & Kamii, 1986) while still providing challenges. Grouping of students in pairs or small groups will provide opportunities for student interaction. Note that the designated grade levels are guidelines only. These activities can easily be modified by using different sets of coins, different target amounts, and/or by omitting or adding procedural steps. A good example may be found in Activity A where the teacher may want to have students simply count the number of heads and tails for each coin after successive drops.

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STUFF

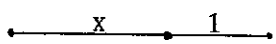
Strategic Tactics Ultimately For Fun

THE GOLDEN RATIO
AN APPLICATION OF QUADRATIC FORMULA

by Marsha Hurwitz

Duchesne Academy, Houston, Texas 77024

The Golden Ratio provides a good application of the quadratic formula. A line segment is said to be divided into the "golden ratio" if the ratio of the larger part to the smaller part is equal to the ratio of the whole segment to the larger part. Thus, if the segment below is subdivided into the golden ratio and consists of segments of length x and 1, then $x/1 = (x + 1)/x$ or $x^2 - x - 1 = 0$.



We find by solving this quadratic that $x = (1 + \sqrt{5})/2$, the familiar quantity designated as the "Golden Ratio." Similarly, a rectangle is called a "golden rectangle" if the ratio of its length to width is the golden ratio.

Before the lesson begins, ask a student to draw what he/she feels is a typical rectangle. This student has no knowledge of the "golden rectangle" at this time. After discussing the properties of the golden rectangle, and that this rectangle is said to be more pleasing to the eye than a rectangle of other proportions, proceed to measure the dimensions of the student-constructed rectangle. Hopefully, the student's rectangle will have length and width whose ratio is close to $(1 + \sqrt{5})/2$ or approximately 1.6. Admittedly, this occurrence only happens about 50% of the time, but when it does it is impressive to the students.

Later when students study optimization problems, pose this problem: You want to build a rectangular fence for your garden with perimeter p. Is the most attractively shaped garden necessarily the one that will yield the most area for the given perimeter of fencing? The rectangle yielding the largest area is a square with sides p/4. Students can then compare the area of the "most attractive" rectangle, (the golden rectangle) with that of the square.

During a subsequent class period begin the lesson by announcing that today is the day for the annual beauty pageant. Cajole a couple of students to act as contestants and recruit two extra aides to take measurements. The aides measure each contestant's height as well as the distance from the navel of each student to the floor. The class will be intrigued as to why these measurements are being taken. After asking them to compute the ratio of height to navel distance, the answer is apparent. Both ratios are approximately 1.6, and the student whose ratio is closed to $(1 + \sqrt{5})/2$ wins the beauty pageant. The other student is, of course, first runner up.

Students will enjoy these exercises as practical and humorous applications of the quadratic formula and the golden ratio.

*The inspiration for this activity came from Dave Van Ness of Episcoal High School in Houston.

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π 5!

MATH

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