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Using String Figures to Teach Math Skills

Part 1: The Diamonds System

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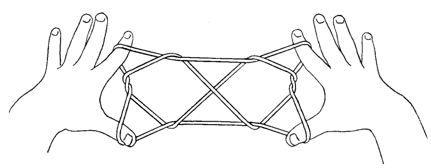

ABSTRACT

The ability to think in abstract terms is unique to the human species. Math is the most powerful and manipulable abstract language available to us. Unfortunately, today's students are often "math shy" and as a result, never acquire the mental skills needed for higher thinking. String figures are a visually pleasing and wonderfully tactile way of learning to appreciate complex consequential phenomena. This article presents the first of four string figure "systems" developed by the author for teaching students how to think systematically.

FOREWORD - *by Gelvin Stevenson*

For over a decade, Jim Murphy has pioneered the practice of using string figures to teach math skills at LaGuardia High School of Music and the Arts in New York City. His philosophy was the subject of an article I contributed to volume 2 (Stevenson 1995). According to Jim, the visual, manual, and aesthetic dimensions of making string figures attract students who are otherwise bored with standard math classes. In learning to manipulate and systematically vary string patterns, students inadvertently begin thinking in an abstract language (see Bluestone's *New York Times* article for further details).

Over the years string figures, combined with Jim's own forceful and memorable personality, have ignited sparks of learning in countless students whose flames of intellectual inquiry had been doused by the rough and tumble life of New York City. Jim, who is Cherokee like myself, taught me that string figures are a journey without end, a journey that spans the globe and all of human history. Thanks, Jim — in Cherokee, *Wado*.

INTRODUCTION - *by James R. Murphy*

The following material is from a book Gelvin and i* are writing tentatively titled "String Figures by Learning Hands." The book, written in the style of a laboratory manual, is a compilation of lecture notes i prepared over the years for my "String Figures" course. The course is designed to teach reluctant math students how to think abstractly within the confines of a rigidly defined system. Algebra, geometry, calculus, and string figures each have a unique set of procedures for keeping order. Within each discipline, students learn the procedures, practice them, abstract them, then learn to apply them to more complex problems.

In the course i teach, several basic string figure families or "weaving systems" are examined in great detail. These include the two-loop *Diamonds* system (figures related to Jayne's Osage Two Diamonds), the three-loop *Ten Men* system (Jayne 1962:150-156), several three-loop *North American Indian Net* systems (Jenness's Fish Net, Jayne's Many Stars, Owl's Net, and Apache Door), and several four- and five-loop *Complex Net* systems (various Pacific Island figures). Within each system, an ordered exploration of how to vary the parent design is undertaken. Subsequent lessons focus on how to link the systems to create even more complex designs.

The editors, in preparing the following highly condensed version of our *Diamonds* chapter for the Bulletin, have eliminated our introduction and much of the supplemental material we use to attract and maintain the interest of students. Readers are encouraged to consult the full text for a more comprehensive and entertaining presentation of the material.

Osage Two Diamonds - a simple two-loop system

Osage Two Diamonds was first described by Caroline Furness Jayne, who learned it from an Osage Indian (Jayne 1962:28-30). Throughout this article

*In referring to myself i use either my Cherokee name, inoli, which means "Black Fox," or the lower case "i." English is a language in which the first person singular pronoun is capitalized. My grandfather used the lower case i to delineate how he was no more important than anyone else in the group. So do i.

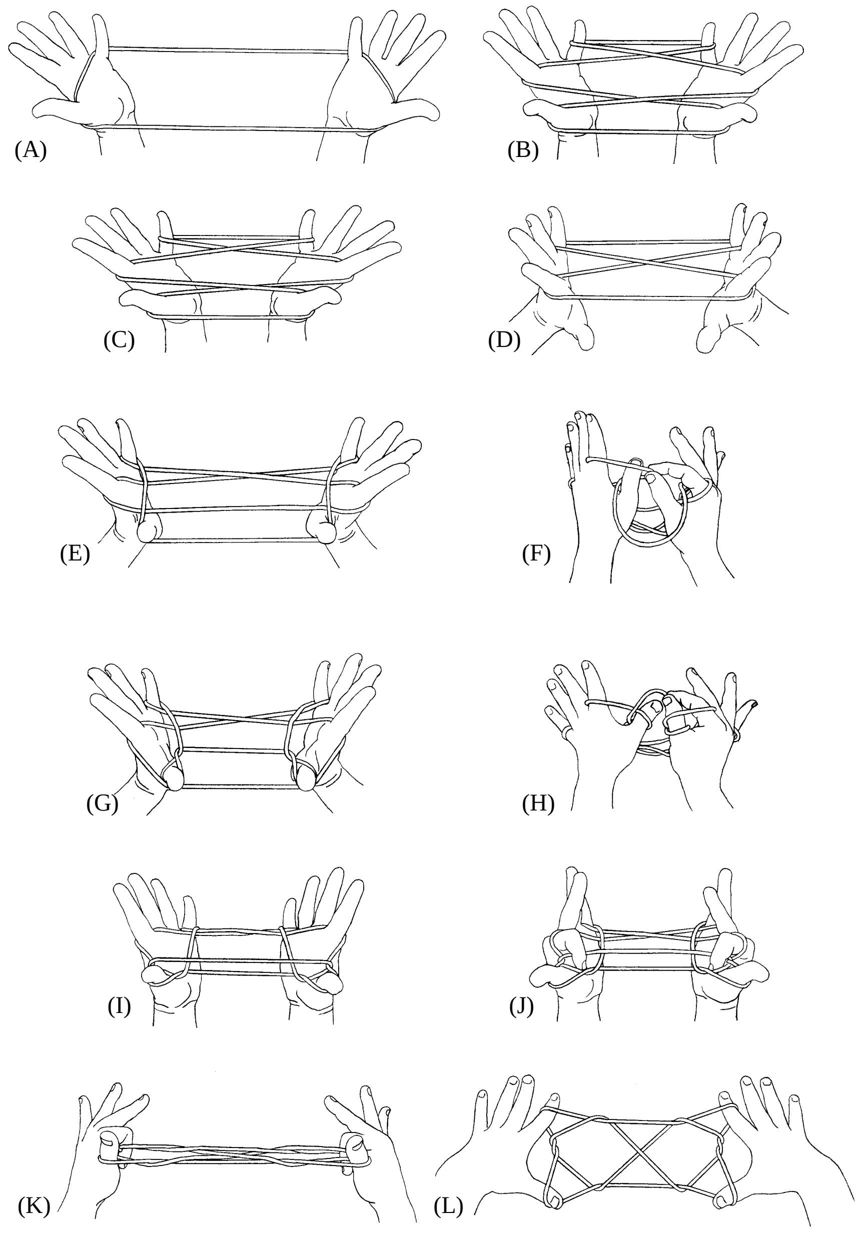

Fig. 1 - *Stages in making Osage Two Diamonds*

i tend to use her vocabulary for describing how string figures are made, with terms of my own invention added intermittently for flavor. To facilitate the introduction of variations, the method of manufacture has been divided into three phases: *Loom Phase*, *Weaving Phase*, and *Extension Phase*.

Loom phase

- Begin with Position 1 (fig. 1A), followed by Opening A (fig. 1B). Note that in Opening A, the left palmar string is retrieved first. If the right palmar string is taken up first, you have what i call Opening B (fig. 1C).
- Drop the loop from your thumbs and pull your hands apart to generate the basic two-loop loom (fig. 1D).

Weaving phase

- With your thumbs, reach away from you, over three strings, and pick up the fourth string (the far little finger string) from underneath. Return the thumbs to their starting position (fig. 1E).

Extension Phase

- Use the thumb and index of your right hand to pick up the segment of the left near index string that lies between the left index and the left palmar string. Drop it over the left thumb (fig. 1F), then repeat on the right and separate the hands (fig. 1G).
- With the help of the right hand, *navaho* the left thumb loops (lift the lower loop over the upper loop and release it, fig. 1H). With your left hand navaho the right thumb loops and extend (fig. 1I). This move is named after the Navaho Indians (the Diné people), who use it frequently in making string figures (Haddon 1912:5).
- Turn the palms toward you and note the triangles formed between the thumbs and index fingers. On each hand, place the index finger into this triangle and press it against the palm (fig. 1J).
- Slide the loop off each little finger (use the right little finger to slide the loop off the left little finger and vice versa) and separate the hands to absorb the slack (fig. 1K). Note: The string concealed beneath your bent index finger will become the upper frame string of the design — don’t drop it.
- Rotate and open your hands away from you as if you were getting ready to catch a volleyball thrown shoulder-high. As you roll your hands, your thumbs will point toward you, then down, then toward each other; your index fingers will point away from you and then up as you straighten them. The result is Osage Two Diamonds (fig. 1L).

For about 95% of all students, one or both strings fall off the index fingers during the first few tries. i remind them that practice makes perfect, and that with practice, the hands will learn to dance smoothly as the figure is formed.

SIMPLE VARIATIONS OF OSAGE TWO DIAMONDS

Once my students have mastered Osage Two Diamonds, i teach them how to vary the design by twisting some or all of the loops of the two-loop loom (fig. 1D). The results are one diamond, three diamonds, or four diamonds.

One Diamond

Loom Phase: same as Osage Two Diamonds
Weaving Phase

- Bring the hands together, and with the left thumb and index finger grasp both strings of the right index finger loop (near the base of the finger). Twist the right index finger toward you, down, away, and back up to where it started, then let go of the strings held by the left thumb and index. In a similar fashion, twist the right little finger loop a full 360º toward you (fig. 2).
- With your thumbs, reach away from you, over three strings, and pick up the fourth string (the far little finger string) from underneath. Return the thumbs to their starting position.

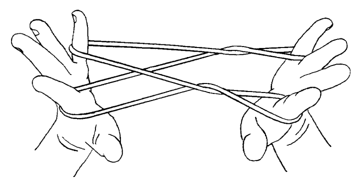

Fig. 2 - *Twisted 2-loop Loom*

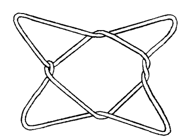

Fig. 3 - *One diamond*

Extension Phase: Same as Osage Two Diamonds. The result is One Diamond (fig. 3).

Three Diamonds

Loom Phase: same as Osage Two Diamonds
Weaving Phase: Same as One Diamond, but twist the *left* index and *left* little finger loops a full 360º towards you.
Extension Phase: Same as Osage Two Diamonds. The result is Three Diamonds (fig. 4).

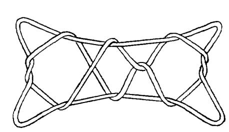

Fig. 4 - *Three diamonds*

Four Diamonds

Loom Phase: same as Osage Two Diamonds
Weaving Phase: Same as One Diamond, but in addition to twisting the right index and right little finger loops, also twist the left index and left little finger

loops (in other words, twist all four loops a full 360º toward you).
Extension Phase: Same as Osage Two Diamonds. The result is Four Diamonds (fig. 5).

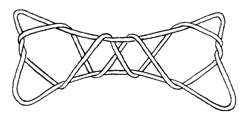

Fig. 5 - *Four diamonds*

Variations with Opening B

i also encourage my students to make all of the above starting with Opening B. The results are rather surprising — One Diamond gives Three Diamonds and Three Diamonds give One Diamond (with minor differences in string crossings).

Jacob's Ladder

By the end of the first session most of my students have acquired the confidence needed to tackle Osage Four Diamonds (Jayne 1906:24-27), otherwise known as *Jacob's Ladder*. i mention to them that in this four-diamond figure, wraps rather than simple crossings are present where the center two diamonds join the outer two diamonds. To refresh your memory, here is how it is made:
Loom Phase: Same as Osage Two Diamonds.
Weaving Phase

- Pass the thumbs *under* all four strings and bring back the far little finger string.
- On each hand, reach over the near index string with your thumb, pick up the far index string, and return. Drop the little finger loops.
- On each hand, reach over the near index string with your little finger, pick up the far thumb string, and return. Drop the thumb loops.
- On each hand, reach over both index strings with your thumb, pick up the near little finger string, and return.

Extension Phase: Same as Osage Two Diamonds. The result (ISFA's logo!) is shown in fig. 6.

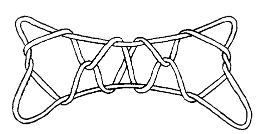

Fig. 6 - *Jacob's Ladder*

Multipliers

Next i introduce my students to two repetitive techniques for adding more diamonds to any of the five figures described above. These are: *Storing Two Diamonds* and the *Rastafarian Addition*.

Storing Two Diamonds

Loom Phase: Same as Osage Two Diamonds.
Weaving Phase

- Pass the thumbs *under* all four strings and bring back the far little finger string.
- On each hand, reach over the near index string with your thumb, pick up the far index string, and return. Drop the little finger loops.

So far, the method is identical to Jacob's Ladder. Now we introduce a modification:

- On each hand, with your little finger reach over *two* strings (the near index string and the far thumb string), then under both of the near thumb strings, and return with the lower near thumb string (a bit awkward, but practice makes perfect). Drop the thumb loops and pull your hands apart (fig. 7).

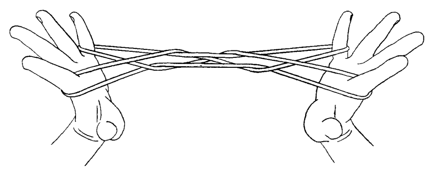

Fig. 7 - *Two diamonds stored*

You have just *stored two diamonds*. In fact, if you move your hands around a bit you can catch a glimpse of the two embryonic diamonds near the center. If you now complete the weaving and extension phases of Osage Two Diamonds, you get "two plus two" or *Four Diamonds* (fig. 8).

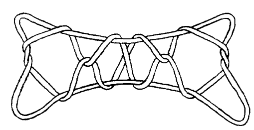

Fig. 8 - *Four diamonds*

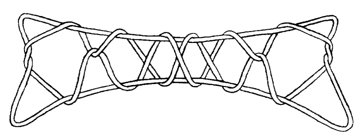

Fig. 9 - *Six diamonds*

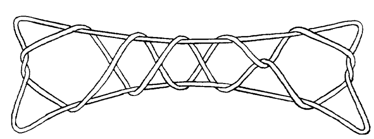

Fig. 10 - *Five diamonds*

To make *Six Diamonds* (fig. 9), store two diamonds, then store two diamonds again, and finish with Osage Two Diamonds (weaving phase plus extension phase). The technique is additive: the number of diamonds is limited only by the length of the string and your ability to extend the final figure without the center collapsing. One can also make Six Diamonds by storing two diamonds, then finishing with Four Diamonds, or by finishing with Jacob's Ladder (the entire weaving phase plus the extension phase).

An odd number of diamonds is also possible. To make *Five Diamonds* (fig. 10), store two diamonds, then finish with Three Diamonds (weaving phase plus extension phase). Surprisingly, Five Diamonds are also obtained if one stores two diamonds then finishes with One Diamond. The only difference between the two designs is the location of the single internal wrap. To make *Seven Diamonds*, store two diamonds twice, then finish with either Three Diamonds or One Diamond.

Students enjoy exploiting the additive nature of the *storing two diamonds* technique. The ability to intelligently build a string figure with the desired number of diamonds is tremendously satisfying. Students are encouraged to record the results of their experiments in a table to help them conceptualize the material.

Start with...	...finish with...	...and get:
Storing Two Diamonds	Osage Two Diamonds	Four Diamonds
Storing Two Diamonds twice	Osage Two Diamonds	Six Diamonds
Storing Two Diamonds	One Diamond	Five Diamonds
Storing Two Diamonds	Three Diamonds	Five Diamonds
etc...	etc...	etc...

The Rastafarian Addition

Another useful technique for increasing the number of diamonds is a continuation move taught to me by a Rastafarian from Jamaica who sat next to me on the flight home from a Native American Educator's conference i had attended. The technique adds another diamond to each end of any finished diamond figure (or any other figure which has four loops as its extending framework). Like *storing two diamonds*, the technique can be applied over and over again. To illustrate the technique, begin with Jacob's Ladder, then append as follows:

- Pass your thumbs away from you, under the figure, and at the same time point your fingers toward you so that your palms face upward. At this point, the diamonds will lie parallel to the ground (fig. 11). Note the half twist in each thumb loop.

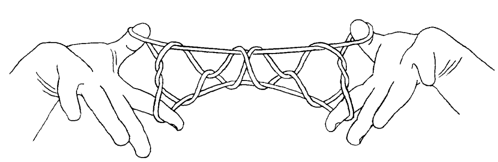

Fig. 11

- On each hand, transfer the half-twisted thumb loop to your little finger, maintaining the half twist throughout the transfer (fig. 12).
- On each hand, pass your thumb over both index strings, pick up the near little finger string, and return.
- Now finish by completing the extension phase of Osage Two Diamonds. The result is *Six Diamonds* (fig. 13), but with unusual wraps between diamonds 1-2 and 5-6. To make *Eight Diamonds*, simply repeat the above.

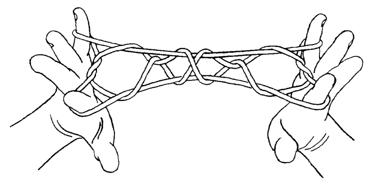

Fig. 12

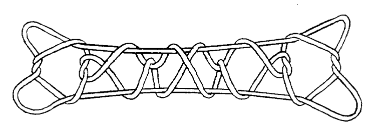

Fig. 13 - *Rastafarian six diamonds*

Many students will attempt to form eight or more diamonds using either of these two techniques, only to find that the center of the figure tends to collapse as its complexity increases. This is a disappointing but inevitable outcome. It is for this reason that i invented what i call the *Power Lift*.

The Power Lift

The Power Lift is a technique for improving the extension of figures that tend to collapse when drawn taut. The technique can be applied to any figure in which only four loops are present on the hands in the final extension. It is most effective when the string is thin and somewhat slippery (nylon, satin, or silk).

- Make and extend a Diamond figure (here i use Jacob's Ladder as an example).
- Turn your hands inward so that your palms are facing you (fig. 14). With the help of the opposite hand remove the index loop, untwist it by rotating it a half turn away from you, and place it on the little finger. The diamonds now lie parallel to the ground and the loop on each thumb and little finger is free of twists (fig. 15).

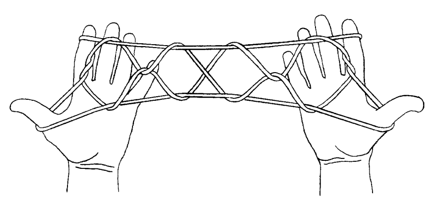

Fig. 14

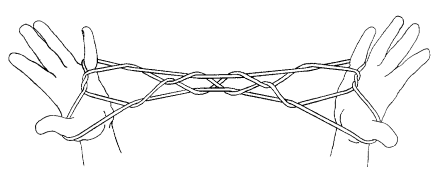

Fig. 15

- On each hand, with your thumb pick up the near little finger string, close to the little finger, (the string is very short!), and return.
- On each hand, bring the index and middle finger toward you, over both strings of the upper thumb loop, and using them as "pincers," sandwich the lower near thumb string between the two fingers (fig. 16), then wrap the string around the tip of the index by rotating the pair away from you and up, lifting the string over the upper thumb loop as you straighten the fingers (fig. 17). Separate the index and little fingers as far as possible, while simultaneously pushing the thumbs towards the center of the figure (note that each thumb is held tightly by two circlets of string). With a little practice, the figure will spring dramatically to life (fig. 18). One can even make the figure "dance" by sliding the thumbs back and forth across the surface of the design.

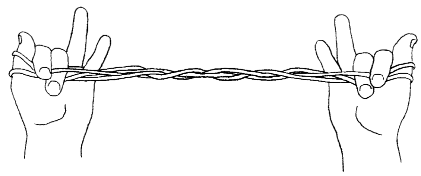

Fig. 16

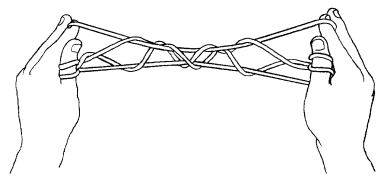

Fig. 17

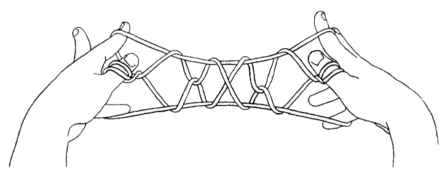

Fig. 18 - *Jacob's ladder power-lifted*

i CANNOT OVEREMPHASIZE THE UTILITY OF THE POWER LIFT FOR REVEALING THE INNER BEAUTY OF MANY COMPLEX DESIGNS. All of my students are encouraged to master it at an early stage in their training.

Adding Complexity

One way of adding complexity to our simple two-loop system is to double the number of loops on each finger. This introduces richness to the final design. My students learn two techniques for doubling loops. In the first technique, new loops are created from existing loops using the traditional Inuit *katilluik* move. In the second technique, a four-loop loom is converted to a double two-loop loom by a process i call *conflation* (loop stacking).

Katilluik

Katilluik means "to come together" in Inuktituk (Jenness 1924:12B). Here is how to double the index and little finger loops using the katilluik move (i call this the *Double Katilluik* two-loop loom*)*:

- Create the basic two-loop system (Opening A, drop the thumb loops).
- To katilluik the index loops, bring the hands together, insert the right index, from below, into the left index loop and lift it off the left index entirely; then insert the left index (which is now free of loops), from below, into both loops on the right index finger and separate the hands. You now have two loops on each index, one of which has a transverse far string (fig. 19).

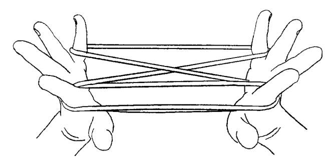

Fig. 19

- To katilluik the little finger loops, bring the hands together, insert the right little finger, from below, into the left little finger loop and lift it off the left little finger entirely; then insert the left little finger (which is now free of loops), from below, into both loops on the right little finger and separate the hands. You now have two loops on each little finger, one of which has a transverse near string (fig. 20).

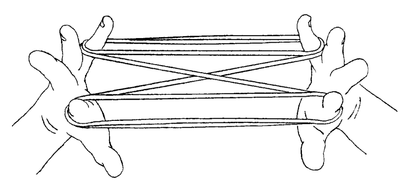

Fig. 20 - *Double katilluik two-loop loom*

Now try forming Osage Two Diamonds with this loom, treating all doubled strings as single strings. The result is *Double Katilluik Two Diamonds*: a two diamond pattern with double framework strings and two parallel transverse strings running across the center (fig. 21). *Double Katilluik One Diamond* actually has three diamonds, and central transverse strings which loop around the framework strings (fig. 22). *Double Katilluik Three Diamonds* also has three diamonds, but the central transverse strings are now woven into the inner design (fig. 23). *Double Katilluik Four Diamonds* resembles the two-diamond equivalent (fig. 24).

Once these variations are mastered, i encourage my students to experiment with a two-loop loom in which only the index or only the little finger loops are doubled using the katilluik move (*Single Katilluik* two-loop looms). When the former case is applied to Jacob's Ladder, a four-diamond figure crossed by a single central transverse results, as shown in fig. 25 (take care to retrieve only the non-transverse far index string in the second step of the

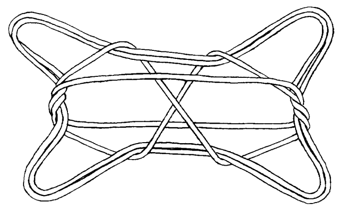

Fig. 21 - *Double katilluik two diamonds*

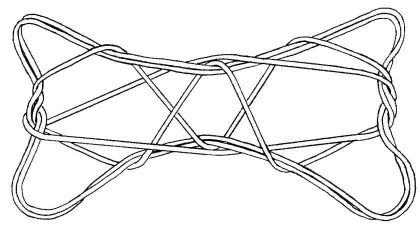

Fig. 22 - *Double katilluik one diamond*

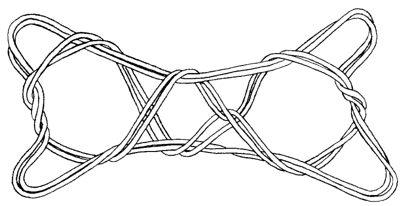

Fig. 23 - *Double katilluik three diamonds*

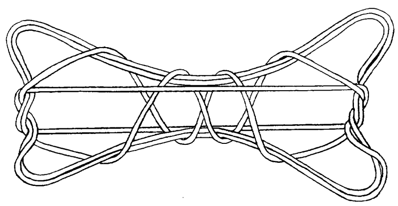

Fig. 24 - *Double katilluik four diamonds*

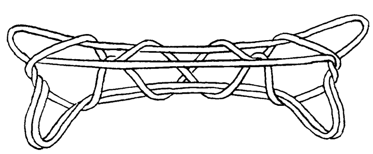

Fig. 25 - *Single transverse ladder*

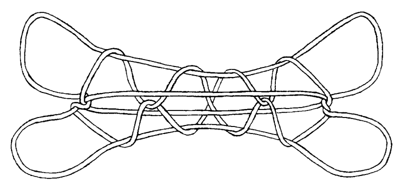

Fig. 26 - *Double transverse ladder*

weaving phase). Alternatively, one can start with a double katilluik two-loop loom, but pick up only one strand of each double string during subsequent weaving steps. A little experimentation with Jacob's Ladder leads to a pleasing pattern with two central transverse strings (fig. 26).

Loop Conflations

Loops can also be doubled by stacking or "conflating" them. To conflate Opening A (a three-loop loom), transfer the thumb loops to the index fingers. Now weave Jacob's Ladder. The result is another interesting variation with added complexity (fig. 27). Some of the most interesting variations derive from conflating four-loop looms down to double two-loop looms. One of my favorite openings is the *DNA four-loop loom*:

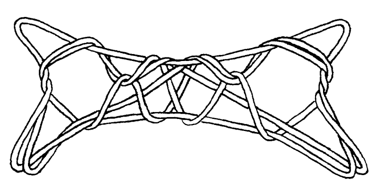

Fig. 27

- Opening A, then drop the thumb loops to give a two-loop loom.
- Insert the right thumb, from *above*, into the left index loop and return with the left near index string. A tight circlet of string forms around the right thumb.
- Insert the left thumb, from below, into the right thumb loop (the circlet) and separate the hands. The result (fig. 28), resembles Opening A, but if you point the fingers of the right hand away from you, you will notice that none of the strings touch, and that the figure is somewhat reminiscent of a DNA spiral. This i call a *DNA three-loop loom*.

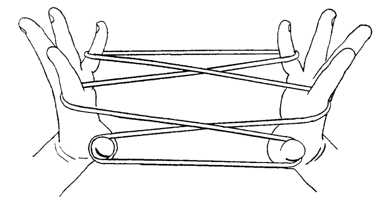

Fig. 28 - *DNA three-loop loom*

- To continue and make a *DNA four-loop loom* (fig. 29), transfer the index loops to the middle fingers and the thumb loops to the index fingers, then repeat Steps 2 and 3. Again, if you point the fingers of the right hand away from you, none of the strings will touch.

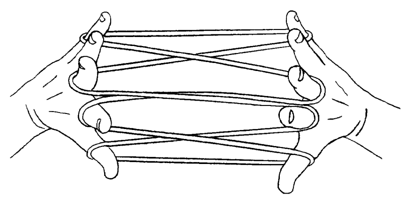

Fig. 29 - *DNA four-loop loom*

Now, let’s conflate the DNA four-loop loom:

- Transfer the thumb loops to the index fingers, the little finger loops to the middle fingers, then transfer both sets of middle finger loops to the little fingers. You now have a DNA four-loop loom conflated into a two loop reality (fig. 30).

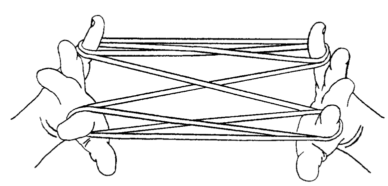

Fig. 30 - *Conflated DNA four-loop loom*

To finish our little experiment, weave Osage Two Diamonds and extend (fig. 31). The result is a two-diamond pattern with a criss-crossed “web” or “net” superimposed upon it. You might also try weaving One Diamond (fig. 32), Three Diamonds (fig. 33), and Four Diamonds (fig. 34) starting with a conflated DNA four-loop loom.

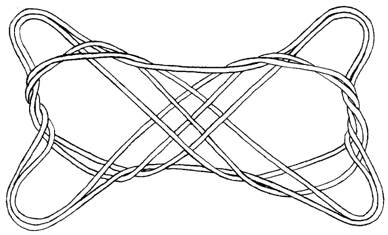

Fig. 31 - *Conflated DNA two diamonds*

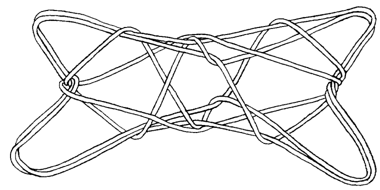

Fig. 32 - *Conflated DNA one diamond*

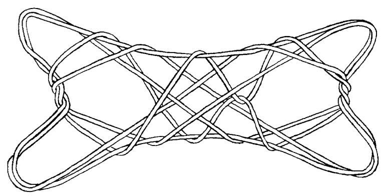

Fig. 33 - *Conflated DNA three diamonds*

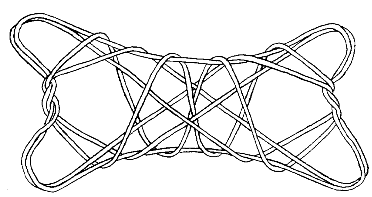

Fig. 34 - *Conflated DNA four diamonds*

Weaving Diamonds with a Two-Color String

Having mastered the five basic diamond patterns as well as their Katilluik and Conflated DNA loom equivalents, students begin to understand how to introduce complexity into their designs. However, at this stage it is not at all obvious how various parts of the loom give rise to various components of the final design. Which loom strings give rise to the final framework? Which give rise to the inner complexity (the crossing strings) of the design?

For this level of analysis, a loop made of two differently colored segments is indispensable. One such loop, in which the two colors (here black and white) alternate at 90° intervals, is shown in fig. 35. Complete the *Loom Phase* of Osage Two Diamonds using this loop. If you are careful to have the bands of color change at the fingers (fig. 36), much can be learned about the origins of the string segments in each of our four basic designs:

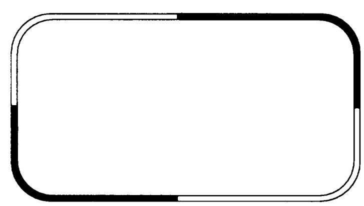

Fig. 35 - *Two-color loop, 90º arcs*

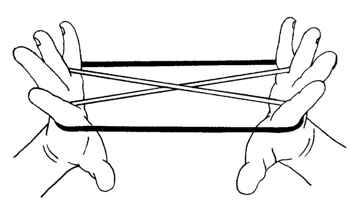

Fig. 36 - *Two-color two-loop loom*

Two Diamonds: As shown in fig. 37, the frame strings arise from the near index and far little finger strings of the loom (the black strings), whereas the

strings that form the diamonds arise from the far index and near little finger strings (the white strings).
One Diamond: Again the same.
Three Diamonds: Again the same.
Four Diamonds: Again the same.

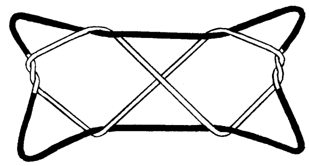

Fig. 37 - *Two-color two diamonds*

There doesn't seem to be much happening here except the division of the circle into frame one color and complexity another. But suppose we were to further divide the circle into eighths, with each band of color defining a 45 degree arc (fig. 38), then weave the four basic figures using a two-color Double Katilluik Loom (fig. 39). What would happen then?

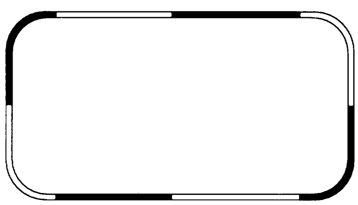

Fig. 38 - *Two-color loop with alternating 45º arcs*

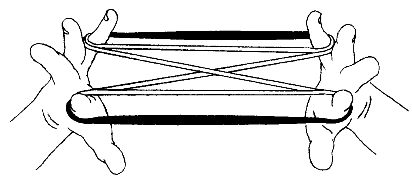

Fig. 39 - *Two-color double katilluik two-loop loom*

Two Diamonds: Again the framework (which now consists of double strings) is black and the "complexity" is white (fig. 40).

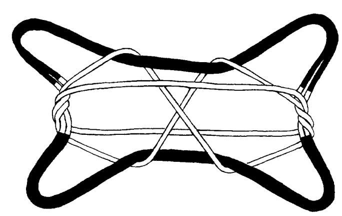

Fig. 40 - *Two-color double katilluik two diamonds*

But there are more things happening here than you might at first guess. We need a method for identifying where each of the white segments of the circle end up in the final design. One way of addressing the problem is to number the white segments consecutively around the circle with one stripe, two stripes, three stripes, and four stripes (fig. 41). Now set-up the Double Katilluik two-loop loom so that the white segments form the interior strings and the black segments form the double near index and far little finger strings. Try to make the "1-stripe" string be the transverse on the far side of the index, the "3-stripe" string be the transverse on the near side of the little finger,

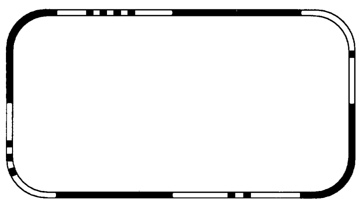

Fig. 41 - *Two-color loop with white arcs numbered*

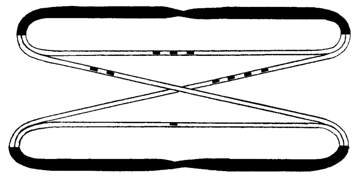

Fig. 42 - *Two-color double katilluik two-loop loom, numbered*

and the “2- and 4-stripe” strings be the strings that cross in the center (fig. 42). Other configurations are certainly possible, but for the moment try this one. Also, make sure that when placing the loop on your hands in Position I, the numbered segments increase in value as you proceed clockwise around the loop when viewed from above. If you don’t adhere to this convention, much of the ensuing discussion will not make sense. Now, form and examine the Double Katilluik Two Diamonds figure. You will notice that the two central transverse strings are the 1-stripe and 3-stripe strings while the crossing “complexity” strings are the 2-stripe and 4-stripe strings (fig. 43). This is somewhat surprising!

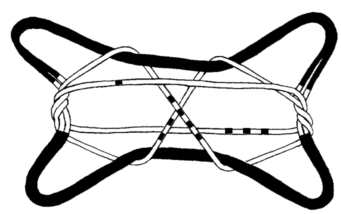

Fig. 43 - *Two-color double katilluik two diamonds*

Next, conflate a DNA four-loop loom into a two loop reality. Shift the segments until the white 1-stripe and 4-stripe strings criss-cross between the index fingers, and the 2-stripe and 3-stripe strings criss-cross between the little fingers (fig. 44). Now the figure formed upon applying the Osage Two Diamond weaving and extension phases has black strings forming the two diamonds and white strings forming the “web” superimposed on them, with the 2-stripe and 3-stripe strings crossing on the front side of the figure and the 1-stripe and 4-stripe strings crossing on the back side (fig. 45). Things are not as simple as before!

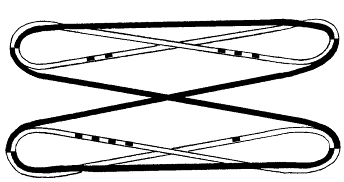

Fig. 44 - *Two-color conflated DNA two-loop loom, numbered*

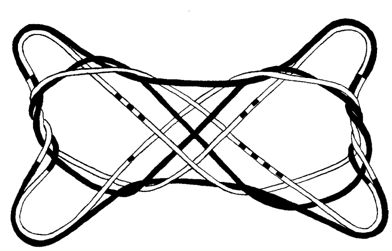

Fig. 45 - *Two-color conflated DNA two diamonds*

Let's skip the *One Diamond* and *Three Diamonds* figures for a moment and move directly to investigating the *Four Diamonds* figure with the Double Katilluik and Conflated DNA geometries. With the Double Katilluik two loop loom the *Four Diamonds* weaving sequence produces a figure with the four diamonds formed by the 2-stripe and 4-stripe strings, and the double transverse strings in the center formed by the 1-stripe and 3-stripe strings (fig. 46). With the conflated DNA four-loop loom the *four diamonds* weaving sequence produces four diamonds formed by the black strings and a web formed by the white (striped) strings (fig. 47). If you examine the striped strings from left to right as they intersect with the top framework string, their order is: 3-4-1-2. If, by accident, you placed the loop on your hands in Position I so that the numbered segments increase in value as you proceed *counterclockwise* around the circle, their order in the final design would be 2-1-4-3! In fact, the outcome can be predicted by noting the identity of the 1-stripe and 4-stripe strings in the conflated DNA four-loop loom: if the 1-stripe string travels from the near side of the left index to the far side of the right index, then the order of the strings in the final design will be 3-4-1-2, implying that the numbered segments increased in value as you traveled clockwise around Position I. But, if the 1-stripe string travels from the far side of the left index to the near side of the right index, then the order is 2-1-4-3, and the values increased in a counterclockwise direction.

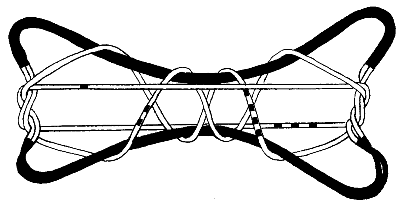

Fig. 46 - *Two-color double katilluik four diamonds*

If you are wondering what is happening with the non-web strings, you can arrange the conflated DNA four-loop loom so that the transverse near index string is the 1-stripe string and the transverse far little finger string is the 3-stripe string. This figure, when formed with the Four Diamonds weaving sequence, has the white 3-stripe string as an upper framework (transverse index) string and the white 1-stripe string as a lower framework (transverse thumb) string. The four diamonds in the middle are formed by the white 2-stripe and 4-stripe strings (fig. 48).

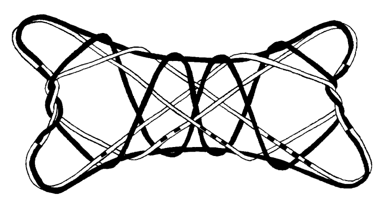

Fig. 47 - *Two-color conflated DNA four diamonds, white web*

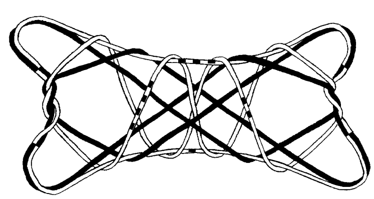

Fig. 48 - *Two-color conflated DNA four diamonds, black web*

To really challenge my students i encourage them to try rotating the loops of the conflated DNA four-loop loom in all possible ways (+ means away from you, – means towards you):

Index loop	Little finger loop
–	–
+	+
–	+
+	–

i would call your attention especially to the pattern formed by the + + combination. In this design, the intersecting strings of the two central diamonds (white 2- and 4-stripe strings) are locked within the quadrilateral created by the black web strings where they criss-cross in the center. i also ask my students to consider the consequences of twisting the four loops of the DNA four-loop loom individually, before conflating them (sixteen possible permutations of + and –). The results are again informative.

Several paragraphs ago i asked the reader to postpone thinking about the One Diamond and Three Diamond figures made with the Double Katilluik and Conflated DNA four-loop looms. Their geometries are extremely interesting. My absolute favorite is *Three Diamonds* woven on a conflated DNA four-loop loom (fig. 49). Here, the single upper and lower framework strings and the strings forming the three diamonds are black, and the superimposed four-string web is white. Thus you have an asymmetrical three-unit motif and a symmetrical four-unit motif in the same figure. By reversing the color polarity as i did in the Four Diamonds example, it's possible to determine that the framework strings derive from the 3-stripe and 1-stripe strings, while the 2-stripe and 4-stripe strings form the three diamonds.

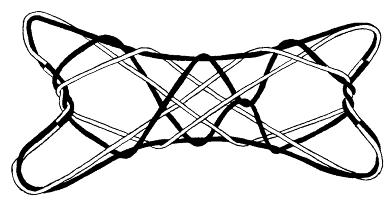

Fig. 49 - *Two-color conflated DNA three diamonds*

The consequential topologies of the circle's folding in on itself in this rather trivial series of figures (when thinking of what is normally done with three-loop figures, for example) make one understand what a rich and wonderful mathematics is contained in string figures. i have been exploring the more complex configurations for about a month now and am overwhelmed.

SUMMARY

My basic premise is that math is the study of the abstraction of patterns, and that the peculiar power of math lies in its ability to reduce complexity to controllable procedural patterns. The Diamonds system is a fairly simple suite of figures, the forming of which teaches a great deal about organization of effort and the particularization of differences. My three-year-old daughter learned the Diamonds system while riding with me to school each morning on the bus. You would be amazed at how quickly students will push for their own figure once they pick up speed and begin to experience success in their searching. Thus, one can "learn to learn" mathematics, and/or any other intellectual pursuit, by what a successful experience with string figures teaches.

For a more explicitly modern and practical use of string figures, consider what they teach about modular thinking and, therefore, computer programming. A simple example of modularity occurs within the Diamonds system, where a module of two diamonds can be created and stored, to be added to any of several string figures. This is a perfect introduction to modern high level computer languages and their modular approach to complex programming. More advanced applications of modularity occur when new figures are created using movements borrowed from several different weaving systems. These systems, and methods of linking them, will be explored in future installments of "Using String Figures to Teach Math Skills."

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