Turtling Around in Circles

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"There are 360 degrees in a circle."

Did you have to memorize this in elementary or junior high school? Did you have any idea how exactly 360 of anything would fit into a circle of any size? Did you question your well-meaning teacher, only to become more confused by the well-intentioned reply? And later, in high school, did you "understand" several other geometric theorems that were presented to you, based upon what you already "knew": that a circle has 360 degrees?

I did. Fortunately, my mother, who was a math teacher, had the good sense to help me to explore this confusing idea (even before Logo was a gleam in Papert's eye) by thinking about constructing a circle as a series of line segments and angles of uniform size. In that way, I also was able to see relationships of regular polygons to circles.

Many of my adult students don't have an opportunity to feel this powerful set of related ideas until they begin experimenting with Logo graphics. Their reactions are usually predictably delightful. "So that's what the 360 means!" "Wait! I let my kids loose on this!"

As you probably already know, Papert calls this the Total Turtle Trip Theorem:

If a Turtle takes a trip around the boundary of any area and ends up in the state in which it started, then the sum of all turns will be 360 degrees. (Papert, p. 76)

Just what makes teachers' eyes light up about this particular set of geometric ideas? First is probably their own personal reaction: a long-awaited "ahah!" of comprehension for something that they probably memorized and probably didn't feel that they could fully explain in operational terms to students. But second is the intuitive recognition of a truly powerful idea: as Papert suggests, the students can actually use it, it is more general (it applies to squares and curves, as well as to triangles), and it is intelligible (its proof is easy to grasp). Children that experiment with this idea in the Logo environment will, as Papert says, "come to appreciate how certain ideas can be used as tools to think with over a lifetime." (Papert, p. 76)

The TTTT Applied

What follows is a particularly popular example of one genre of Total Turtle Trip projects explored with children aged 9 - 12. While taking one of my frequent jaunts through a local bookstore, I happened upon one of the more recent of Ed Emberley's drawing books, Picture Pie: A Circle Drawing Book. Prolific Mr. Emberley has produced more than a dozen "how to draw" books still in print that are excellent Logo idea sources for catalyzing procedural code writing. He breaks each drawing down into a logically sequenced series of "picture parts," showing each step in the process in comic strip format. So, too, did he display the how-to's of a magnificent array of designs in his circle book.

The central idea here is to create all images literally using pieces of circles of different sizes. Once the circles themselves are cut from different colors of paper, the only other cuts that should be made are along the radii of the circles, so that each piece looks like a slice of "fraction pie." It's amazing how many different images can be created by varying circle size, portion size, color, material, and placement.

Turtled Circumambience

Picture Pie suggests that students use scissors and colored paper to help them create circle creatures; my third-grade Logo students went one step further. After planning their designs with colored paper pasted to grids (which represented each quadrant of the SETPOS screen), they went about creating their circle sections designs with the turtle. They then decided to create a cooperative class "circles quilt" with the completed designs.

They told me that one of the reasons why this particular structure was so appealing was that they had been playing with the "other part" of circles (the circumference) for so long. As an introduction to the programming part of this project, I drew several circumferences on chart paper for them, and asked how they might color in the circles if they were the turtle and had no FILL command to use. They generated many different methods, such as:
...until one student thought of starting in the center of the circle, rather than along the circumference. Much in the same way that we as teachers immediately recognized the power of the TTIT, a collective gasp, then clamor of voices testified that this was the most powerful (simple, generally applicable) way of coloring in a circle without the FILL tool. The procedure almost wrote itself:

```logo
TO FILL.CIRCLE.OF :RADIUS
REPEAT 360 [FORWARD :RADIUS BACK :RADIUS RIGHT 1]
END
```

(Some of the students were already familiar with the words circumference and radius. I suggested the syntax for naming the procedure.)

How, then, to draw the portions of circles used so cleverly in Ed Emberley's picture pie designs? It was almost immediately apparent:

```logo
TO FILL.HALF.CIRCLE.OF :RADIUS
REPEAT 180 [FORWARD :RADIUS BACK :RADIUS RIGHT 1]
END
```

```logo
TO FILL.QUARTER.CIRCLE.OF :RADIUS
REPEAT 90 [FORWARD :RADIUS BACK :RADIUS RIGHT 1]
END
```

...and so on.

Yes, of course someone suggested a "generic" FILL.CIRCLE procedure (after some circle pie experimentation, naturally):

```logo
TO FILL.CIRCLE :SLICE :RADIUS
REPEAT :SLICE [FORWARD :RADIUS BACK :RADIUS RIGHT 1]
END
```

And someone else decided to make a randomly generated circle slice procedure:

```logo
TO DRAW.RANDOM.CIRCLE
SETH (RANDOM 360)
PU FD (RANDOM 100) PD
SETC (1 + RANDOM 5)
FILL.CIRCLE (RANDOM 360) (RANDOM 120)
END
```

Sample Use:

```logo
REPEAT 30 [DRAW.RANDOM.CIRCLE]
```

Others preferred not to leave the results of their circle composition efforts to chance.

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Powerful Resources

Other how-to-draw books by Ed and Michael Emberley are terrific sources for Logo project ideas, since all sketches are presented first as completed images, then in modular, sequenced steps to show how they were created. Here is a partial list of these helpful procedural graphics resources:

- Drawing Book of Animals
- Big Green Drawing Book
- The Orange Drawing Book
- Big Purple Drawing Book
- Ed Emberley's Drawing Book: Make a World
- Ed Emberley's Drawing Book of Faces
- Ed Emberley's Great Thumbprint Drawing Book
Thinking Like the Turtle

by Bert Eliason

How should we teach Logo?

For the past six years, I have used Logo with students in middle school. I have always told them how to make designs and how to make improvements in their work. The class usually progressed at a fairly rapid clip, but I was the one telling them how to make circles or how they could write procedures. Actually, I was telling them how to do just about everything! The more I read about Seymour Papert and his work with Piaget, the more I came to realize that I wasn’t really asking my students to use their brains—to think for themselves.

This term I decided that I would try encouraging my students to really think. My original hope was that I would be able to discern enough of a difference to decide which style I would continue to use in the future. What I found was unexpectedly exciting and has convinced me to change my teaching style when I introduce and use Logo in the future. I hope that this article renews your faith in what you are doing or encourages you to consider asking students to “think like the turtle.”

Background

The discussion that follows includes my thoughts about and anecdotal recordings of students who were in the process of being introduced to Logo. The students ranged from sixth through eighth grade and had varying ability levels and behavior patterns. The class is an elective that meets during the last period of the school day. The use of Logo described follows a three-day introduction to computers and a five-day course on BASIC programming. This is the first time most of these students have used Logo, though a few students have had some previous experience. We use a lab of 24 Commodore 64’s, which means I do a lot of running around to answer questions, relieve anxieties, and share in student successes.

Day 1: Thinking Like the Turtle

I began by introducing Logo as a programming language that would enable the students to make things on the computer. I told about the beginning of Logo, the use of the floor turtle, and the eventual use of the turtle cursor. I told them that students of all ages have been very successful at using the turtle to draw and solve problems like the ones I would be posing. I told them that we would have fun, but I would expect them to think. In fact, I would ask them to “think like the turtle.” This caused some giggles. I smiled and added, “You’ll see what I mean by that later. Right now, let’s check out Logo.”