

T H E N A T I O N A L
LOGO
E X C H A N G E

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FORWARD 100!

March 1986 Page 1

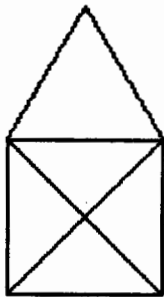
Euler and the Turtle

By Judi Harris

Let's face it, facilitators. Most of us have a Peter Pan or Wendy hiding behind our wise, adult facades, who reign in full glory whenever we sniff Logo in the classroom air! If "growing up" means losing the joyful, experimentative, problem-solving flexibility that is innately child-like, then we Logo-ers must reserve a special corner of our personalities that will never "mature." Chances are you have already done that, and your love for Logo stems partly from the opportunity that it affords to exercise the "never-neverland" option.

Modes of Mischief

Spring is in the air as I write at my Ile, and memories flood back of how that special vernal aroma would incite even the most studious of my childhood friends to mischief! We perfected the technique (we thought) of appearing to listen in class, while really concentrating on something quite different.



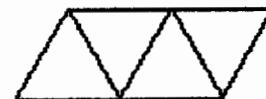
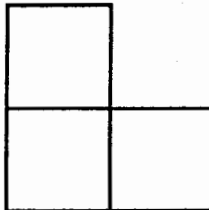
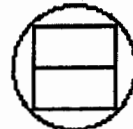
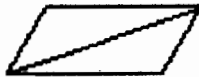
I remember specifically one puzzle "fad" that mesmerized us for several weeks. The challenge was to draw this figure without crossing a line already drawn, or lifting the pencil from the paper. Can you figure out how to do it given those constraints?

We finally did solve the problem, but the "magic" of it remained; some pictures could be drawn this way, and others couldn't. I doubt that any of us realized the inherent mathematical or problem-solving value of such an activity. We also would have been surprised to find out that one of the world's most prolific mathematicians pondered a similar puzzle in the early 18th century. He discovered the reason behind the "magic," also.

Euler and the Opus

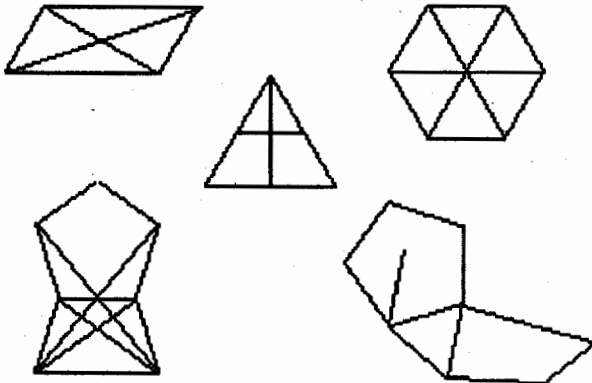
The Swiss mathematician Leonhard Euler (pronounced "oiler") had a Peter Pan in his personality long before Barrie conceived the character. Euler reportedly had 13 grandchildren, and is said to have created mathematical theorems with a baby on his lap and children playing at his feet. He wrote about 800 pages a year of good quality mathematical manuscripts, and is credited with concocting the original ideas of topology.

Enter the 20th century turtle, and the 18th century Euler line drawings like the one at left get a burst of Logo power! Here are some other designs which can be drawn without the turtle's pen going up or its crossing or retracing a line that it has already drawn.



Euler continued

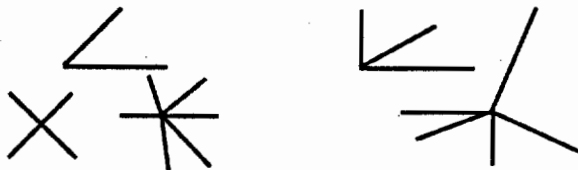
Designs such as these below cannot be produced according to those process specifications.



So what's the "magic?" What do the two groups each have in common within their individual attribute boundaries that is dissimilar across groups? Logo students could pose, consider, discuss, revise, prove, and disprove theories after sufficient experimentation with "turtled" Euler lines. Why don't YOU stop reading for now, and call out your Peter or Wendy to help you play with this?

Euler's Observations

Euler examined the line segments extending from the vertices of polygons and classified the intersections as "even vertices" and "odd vertices."



Even Vertices

Odd Vertices

He observed that the number of *odd* vertices in a figure is always even, and then went on to say:

- If there are no odd vertices in a polygon, then it can be drawn using any vertex as the starting point.
- If there are two odd vertices in a polygon, it can be drawn with Euler lines by starting at one odd vertex and finishing at the other.
- Otherwise, a polygon cannot be drawn without crossing or retracing lines, or lifting the pencil.

What powerful ideas! Do you want to play again, now, before you read on? Or did you already solve the Euler Logo puzzles?

See the Magic

Wise teachers capitalize upon children's natural interests and preferred activities. Why not make a set of polygons that can be drawn according to Euler's specifications? Challenge your students not only to solve the puzzles with the turtle, but to try to see the pattern to the "magic." Most importantly, they could make new Euler line puzzles for their classmates to solve!

Oh - by the way - if your Peter or Wendy wants to check how mine solved the Euler puzzles mentioned earlier in the article, help them to send a stamped self-addressed long envelope to:

Judi Harris
104 Woodside Road, B-306
Haverford, PA 19041

Judi Harris is an elementary school use facilitator in Haverford, PA, and a graduate education instructor for a number of institutes of higher learning. She is also an educational computing consultant whose clients include the Ministry of Education of Kuwait. Her Compu-Serve number is 75116,1207.

From The Editor

by Tom Lough

Educators are enjoined to encourage students to take risks. Taking risks is an important part of the Logo learning environment.

All too recently, we were reminded that the price to pay for taking a risk can be high. In spite of the shuttle tragedy, however, the quest for knowledge continues.

This space is dedicated to the memory of our professional colleague

Christa McAuliffe

and her fellow travelers,
Francis Scobee,
Michael Smith,
Judith Resnick,
Ronald McNair,
Ellison Onizuka,
and
Gregory Jarvis.

May their willingness to take risks be an inspiration to us all.

FD 104!

Tipps for Teachers

by Steve Tipps

Circular Quirks

Two weeks ago in an Introduction to Logo workshop, I loaded the startup file with Apple Logo by accident. In the startup file are the infamous CIRCLEL and CIRCLEAR procedures which draw nice circles. Of course, one or two of the groups found them and used them, while other groups worked steadily toward a circle solution with some frustration and many surprises.

When I asked the CIRCLEAR / CIRCLEL groups to create a circle using REPEAT, they looked at me as if I were crazed. Logo could already make a perfectly good circle without any effort or thinking on their part. Finally, if grudgingly, the preprogrammed circle groups began to use various REPEAT combinations with FORWARD and turns, but they were much less experimental in approach and more willing to accept the first circle they found.

Later in the day, they had projects which required understanding of circles and circle parts. The groups which had spent time playing with the circle were better equipped for the circular quirks found later. (Ed. note: See also "Circles, Arcs, and Headaches," by Sharon Burrowes, in the January 1985 NLX.)

Circles, Circles Everywhere

Experimenting with a circle reveals that a circle is decomposed into "move a little, turn a little, move a little, turn a little," etc. How much is a little? Many times students choose FD 1 RT 1. After some experimenting with REPEAT, they often find that REPEAT 360 [FD 1 RT 1] makes a good circle. I have learned to enforce the idea that a circle is a circle if the turtle starts and stops at the same position and heading. More than a circle or less than a circle is not a circle even if the figure is round. I do not refer to state transparency, but I do insist on the condition.

Having a group invent the REPEAT 360 [FD 1 RT 1] description of a circle is a great first step. An advantage of the description is the clear use of 360.

However, stopping with the circle at this stage leaves the learner with a weak understanding of circle. A teacher who wants a full and powerful understanding of circle challenges students with leading questions. "Can you make the circle bigger or smaller?"

Another way to challenge this circle is to ask for a faster circle. The REPEAT 360 style is so slow that the reason for wanting to speed it up is obvious. Of course, you can hide the turtle to speed up the circle because Logo does not have to redraw the turtle 360 times. But other possibilities are more helpful in understanding the concept of circle.

Good Mistakes

Some learners begin by changing all three of the numbers at once.

REPEAT 75 [FD 7 RT 3] or REPEAT 200 [FD 6 LT 9]

These attempts are good mistakes on the path to circledom because they demonstrate clearly that the three variables interact by making larger, smaller, multiple, incomplete, faster, and slower circles in unanticipated ways. After a bit of good frustration, you might suggest going back to the idea of "move a little and turn a little" as a thinking model for controlling the circle. Instead of using REPEAT at first, try retyping the move and turn lines using <CTRL> and Y (LCSI) or <CTRL> and P (MIT) and follow what is happening. Start out with some patterns to see if you can make a circle with them.

Which of the following will make a circle?

FD 3 RT 3
BK 10 LT 10
FD 10 RT 45
FD 5 RT 15
BK -10 RT 60
FD 30 RT 30

Have the students add combinations of "move a little and turn a little" which make a circle and those which do not. You are hoping they find what conditions exist in all the circle combinations but not in the non-circle combinations. Learners should be able see that the turn a little must be 30 or less. A second relationship which you are trying to elicit is that the number of repetitions times the angles must be 360. Finally, the relationship of the number of repetitions times the "move a little" (or the total number of turtle steps around the outside of the circle) determines the approximate value of the circumference of the circle.

Tips continued

These are tough relationships to learn. Only through experimentation, which may take several hours on the computer over several days, will the learnings be solid. Easy circles with CIRCLEL or CIRCLER leave students with a weak understanding. But consistent work over time provides the background for students to use circles in many ways.

Making Waves

Sailboats are a natural project in Logo -- second only to houses in universal appeal. But what is a sailboat without water and what is water but blues waves across the bottom of the screen? Making waves is a project which employs circle parts. Recognizing that the wave is made of semicircles is easy. Getting the circles to behave properly is the hard part.

After students have a circle which is the right size (and speed), a semicircle is made by halving the number of REPEATs. One semicircle could be made from a circle described by REPEAT 24 [FD 3 RT 15]. Waves are semicircles with a turn of 180 between them.

```
TO SEMICIRCLE
REPEAT 12 [ FD 3 RT 15 ]
END
```

```
REPEAT 10 [ SEMICIRCLE RT 180 ]
```



The waves scallop across the screen just as anticipated with one unanticipated variation. They slant up across the screen rather than being horizontal. Slanting waves are a puzzlement. Why don't they behave properly? The discrepancy can be illustrated by drawing half a hexagon or half an octagon.

```
REPEAT 3 [ FD 10 RT 60 ]
REPEAT 4 [ FD 10 RT 45 ]
```



When half of a figure is drawn, the side does not return to the horizontal line where the drawing began. The same phenomenon is true with half a circle, though the difference is so small it is hard to see except when repeated several times. The diameter is on a slant, therefore the waves are on a slant. You can "cheat" on the semicircle by adding one extra FD to bring the wave back to level.

```
TO WAVE
REPEAT 12 [ FD 3 RT 15 ]
FD 3
END
```

```
TO WAVES
REPEAT 10 [ WAVE RT 180 ]
END
```

**Loop-De-Loop**

Making a loop-de-loop is another intriguing project using circle parts. The first problem is decomposing the loops into a large semicircle and a small semicircle. Slanting occurs with the loops as in the waves. If you "cheat" on the FD, the loops remain horizontal, although not centered.



```
TO LOOP1
REPEAT 12 [ FD 5 RT 30 ]
FD 5
END
```

```
TO LOOP2
REPEAT 12 [ FD 2 RT 30 ]
FD 2
END
```

```
TO LOOP.DE.LOOP
REPEAT 20 [ LOOP1 LOOP2 ]
END
```

Another variation is to add a turn to the LOOPS for CIRCLE.LOOPS. The results for left turns and right turns are very interesting and different.

```
TO CIRCLE.LOOP1
REPEAT 18 [ LOOP1 LOOP2 RT 20 ]
END
```

```
TO CIRCLE.LOOP2
REPEAT 18 [ LOOP1 LOOP2 LT 20 ]
END
```

Variable LOOP procedures add ease and flexibility to the looping.

Tips continued**Circular Thinking**

The workshop brought home to me again the issue of preprogrammed procedures in Logo (See "The Issue of Instant," in the December 1983 NLX). When is it permissible and desirable to provide procedures for students? When is detrimental and undesirable? The answer to the question depends on the goals of the lesson and the tools which are needed to arrive at the goals.

With a group of teachers and most students, the intent in Logo is to provide an experience in problem solving. The problem is how to make a circle. The solution is a circle. Moving from the problem to the solution is the learning. In the process, learners find out that they can control the turtle, make a circle in many different ways, and discover some relationships about angles and perimeters. The knowledge and skills gained prepare the learner for new projects using the circle and its quirks.

Circular thinking in most situations is frowned upon. However, in Logo, thinking about circles is exciting and important. Robbing students of the opportunity of working out the powerful relationships represented in the circle circumvents the learning possible with Logo. Dazzle Draw, Mouse Paint, and MacPaint are great programs with many possibilities including the drawing of the circle; I use each of them to make drawings and pictures. But none of them give me the understanding of circle that is part of Logo, at the heart of Logo.

By the way, there are also a couple of ways you can "cheat" on the semicircles using a turn. One way is similar to the use of FD. The other way is much more subtle (and more elegant).

If you have additional ideas to share, please send them to Steve Tipps, Midwestern State University, 3400 Taft Boulevard, Wichita Falls, TX 76308, or on Compu-Serve at 76606,1623.

Steve Tipps is the West Professor of Education at Midwestern State University in Wichita Falls, TX, and has been involved with Logo since 1982. He conducts Logo workshops for school systems throughout the United States, and is a popular conference speaker.

Logo Study Available

Logo Studies: Observations, Anecdotes, Effects, 1982 - 1985, a book of readings documenting the St. Paul, MN, Logo program, is available to NLX readers for \$2.25. Send your check, made out to St. Paul Public Schools, to Geraldine Kozberg, St. Paul Public Schools, 360 Colborne Street, St. Paul, MN 55102.

Logo Teacher Feature

by *Rebecca Poplin*

Featuring: Mark Mariotti

Very few teachers have the chance to spend most of their time guiding children of all ages into Logo discoveries. Mark Mariotti of Arvada, Colorado, is able to observe the full spectrum of elementary students every day in his job as computer specialist at Stott Elementary School near Denver. In Jefferson County, a major commitment to Logo instruction has been made. Although Logo is used in all 77 elementary schools, only a few of the faculties, like Mark's, have chosen to use a lab setting with a specialized teacher. This gives Mark some unique opportunities to work with students over several years and to observe their development as they use the computer.

Special Opportunities

Recently, Mark took advantage of these opportunities when sixth graders shared with first graders their project of illustrating and printing out nursery rhymes.

The sixth graders used or modified traditional nursery rhymes or created their own. The sixth graders were tremendously proud of their work, especially when the first graders were suitably impressed! The first graders were quite proud, too, when they could read some of the nursery rhymes on the screen. Mark uses older students as lab helpers whenever he can. What a great way for students to learn about each other and about themselves!

Mark has been using tiling activities adapted from the NLX in various ways at different grade levels. Kindergarten students are using shapes that Mark created, Instant Logo, and a stamping procedure to stamp different shapes all over the screen. Shape stamping gives them lots of experience with spatial relations but uses very few Logo commands. Work with patterns ties in closely with classroom work in the *Math Their Way* program.

Turtle Tiling

In the upper grades, Mark has used tiling as a way to introduce the editor. He challenged fourth graders to tile the screen with no overlapping. The third graders have been using tiles to build a frame around the entire screen. For the second graders, Mark wrote a procedure that dots the screen with variable spacing. They use dot paper and connect dots to form certain letters, then transfer the letter to the computer screen. Mark finds that each of his experiences with tiling has been different but really interesting.

Teacher Feature continued

Fifth graders at Stott have been actively involved in a science unit on space exploration, the shuttle, and the solar system. The students have been divided into smaller groups to use the computer to present information on the planets. These projects will be shared with the second and third grades. Mark used box charting with the groups to plan their projects. This planning format really helped students see which procedures were needed and modeled good problem-solving strategies.

The Time Crunch

Like most of us, Mark has found that time is a central issue in using Logo. There are lots of ideas to tie Logo in with the traditional curriculum, but time in the school day is scarce. Many problem-solving activities take the students more time than teachers imagine. Students of all ages need time to think. How do we fit in all the good things and still allow the students to spend all the time they need on a particular problem? Developing teachers' technical knowledge takes time, too.

Computer instruction sometimes seems to be an add-on, but its great potential will help us work through those difficulties, given enough time.

Do you know a teacher who should be featured in this column? Please send recommendations to:

Rebecca L. Poplin
2421 Fain Street
Wichita Falls, Texas 76308

Rebecca Poplin uses Logo to teach computing and mathematics at a junior high school in Wichita Falls, TX.

Logo 86 Announced

Logo 86, the third international Logo conference to be sponsored by the Massachusetts Institute of Technology, is scheduled for July 9 - 11, 1986. A variety of settings will be provided to facilitate the building of Logo networks, including major speakers, presentations, poster sessions, and special interest group meetings. Logo 86 will be preceded by two days of tutorials. Make plans now to attend!

A call for papers has been issued for presentations and poster sessions. Papers from students are especially encouraged. The deadline is March 1, 1986. For more information, contact Brian Harvey, Logo 86 Program Chairperson, MIT, E15-309, 20 Ames Street, Cambridge, MA 02139.

For general conference information, write to Joyce Tobias at the above address.

NLXionary

A Lectionary of Selected Logo Readings

*with Commentary and Opinion
by Griff Wigley*

"Computer Criticism vs. Technocentric Thinking" by Seymour Papert, *Logo 85 Theoretical Papers*, MIT, July, 1985.

>Don't let the title or the first few paragraphs of this piece scare you off, as they did me. Words like 'technocentric' and 'egocentrism' leap from the page in a semantic dare. I'm no match if the house is full of kids, or if I'm tired. But a recent quick scan also revealed subheadings such as "Do not ask what Logo can do to people, but what people can do with Logo" and "Bank Street vs. Kent State" or "Logo: The 'Cabbage Patch Kid' of Computation?" Score one for the Enquirer.

>Papert maintains that asking questions like "Does Logo produce good learning?" or "Does Logo improve thinking skills" are fundamentally the same as asking "Does wood produce good houses" or "Do hammers and saws produce good furniture?" Logo critics (e.g., Roy Pea et al. at Bank Street College) tend to ignore people factors such as skill, design and aesthetics - indeed, the whole culture in which Logo exists. Instead, they gravitate towards a medical model of experimentation, one that works fine for testing the effects of a certain drug, for example. Logo in this context is treated simply as isolated technical knowledge, rather than as one element in a particular type of learning culture.

>He cites the science classroom of George Franz at the Computer School in New York as having a Logo culture in the truest sense ... and whose students appreciate "Logo and the computer in a way that seems beyond the comprehension of many educational psychologists: using the computer not as a 'thing in itself' that may or may not deliver benefits, but as a material that can be appropriated to do better whatever you are doing (and which will not do anything if you are not!)." He compares this school to another in which the more they use Logo, the more they become different. They have different educational goals and use Logo for very different reasons.

>Papert is a believer in systems. If he wasn't a mathematician he'd probably be a family therapist. A behavior problem can be seen as response from within an individual that's part of a linear cause / effect chain. Or it can be seen as one part of a complex, circular interaction that can be simultaneously both cause and result, helpful and hurtful, as it becomes intricately woven into the fabric of the daily lives of the people involved.

NLXionary continued

>At first glance, treatment strategies by one therapist might look the same as those employed by a skilled family therapist. ("Every night that the bed is dry, give him a sticker.") However, the family therapist thinks beyond this simple behavioral strategy and considers the systems in effect. Which parent should give the sticker? How can the grandparents' intrusion be handled? If the wetting is solved, how can the parents be helped with their sexual problem, which the wetting is helpfully distracting them from facing? These are but a few of the issues a systems therapist might consider when treating a problem.

>Likewise, Logo as treatment for education's problems (for example, lack of thinking skills) must be approached in a vein similar to a systems therapist - with the utmost regard to the culture, context, and patterns of interaction in which it is taught and used.

If you would like to respond to this commentary, or know of other Logo related articles and issues which may be of interest to our NLX readers, please write to: Griff Wigley, 918 College Street, Northfield, MN 55057, or send electronic mail to me on CompuServe at 72007,24.

Griff Wigley is a facilitator in the Faribault (MN) Public Schools, and a school board member of Prairie Creek Community School. He and his wife, Robbie, are celebrating the arrival of Gillian Bree Wigley, a beautiful daughter born on January 20, 1986.

Logo Disserts: Dissertations Dealing with Logo

by Barbara Elias

Logo - A Didactic Means of Re-education, by Nicole Michaud, presents some educational applications of Logo as a tool for the individualization of learning and as an environment which can provide experiences for children in temporal, spatial, and causal relationships and concepts. Written in French, the study presents a description of observed behaviors and attitudes of children which evolved as they learned to program. Also included is a case study of an eleven year old boy and his progress in dealing with the problems he experienced with bugs.

Logo is viewed as an environment rich in opportunities for temporal, spatial, and causal experiences. For example, Logo incorporates operators of change, procedures represent temporal sequences and processes, and bugs present challenges with multiple possibilities for accomplishing desired purposes and discovery of new learning.

Children engaged in programming, over time, were observed initially to use a few simple procedures and little or no planning. They subsequently developed the ability to plan and organize projects using procedures and subprocedures, and to work with little support from the teacher. In a similar manner, typical initial attitudes regarding bugs caused a number of denial behaviors -

- (a) hiding the bug by erasing it from the screen,
- (b) ignoring the bug,
- (c) blaming the bug on the teacher or the computer, and
- (d) equating errors with personal failure and incompetence.

Over time, these children were able to use debugging techniques systematically and analyze bugs using physical movement, paper / pencil solutions, and organized searches of procedures.

The case study represents a description and chronology of the Logo learning experiences of an eleven-year-old boy. The boy is described as having learning problems in reading and mathematics, and difficulty in concentration and dealing with failure. He is able to grasp quickly the basics of Logo, but requires help with reading error messages.

After two months of two Logo sessions per week, he still refused to deal with bugs, and showed little planning of his projects. As time passed, however, he began to verbalize his difficulties with errors and to use limited debugging. An individual contract with the teacher was the turning point in his experiences. It assisted him in completing his projects and in ultimately dealing with errors.

At the end of another twenty sessions, he was more relaxed and was able to view bugs with humor and himself as something other than an absolute failure. Programming became an enjoyable experience and he took great pride in his accomplishments. The author notes the limitations of this study but feels that it offers many avenues for future research in learning with Logo.

>>>Michaud, Nicole. *Logo - A Didactic Means of Re-education* (Master of Education Thesis, University of Montreal, December, 1980).

Special thanks to Dr. L. Elie and his students, D. Elder, J. Pratt, M. Scales, and M. Villars, for the translation of this thesis from French into English.

(Ed. note: Each month, Barbara Elias highlights a dissertation or thesis dealing with Logo. She is accepting copies of recent research results for the NLX Dissertation and Thesis Repository. Reports may be mailed to her in care of NLX, PO Box 5341, Charlottesville, VA 22905.)

Barbara Elias is an assistant professor in the Education Department of Virginia State University in Petersburg, VA, and a doctoral candidate at the University of VA.

Listful Thinking

by Glen Bull and Paula Cochran

Summing Up

You can fool some of the people some of the time, but you can't fool the sum of the people all of the time.

A. Lincoln

Most of our "Listful Thinking" columns focus on lists of words, and what you can do with them, such as poetry, conversations, and stories. List operations can be applied equally well to lists of numbers. It's just that by training and temperament we are better qualified to discuss applications in the language arts ... and besides there are plenty of other people willing to talk about computers and numbers.

However, there are many list applications for numbers which are easy and fun. They can even be used in the social sciences, believe it or not. This month we are going to take a detour, and take a quick look at lists and numbers.

Number Sums

Everyone knows that Logo can add numbers.

```
?PRINT 2 + 3 + 7
12
```

In many versions of Logo, the same result can be obtained using the following command format:

```
?PRINT (SUM 2 3 7)
12
```

Terrapin Logo does not have a built-in procedure called SUM. However, don't worry. In just a moment we will give you a short procedure called ADD that does the same thing.

Why would you ever want to use SUM instead of a plus sign? Well, suppose that we had a group of numbers we wanted to add:

```
3 5 7 2 6
```

One way to add the list of numbers would be to put plus signs in between each of the numbers:

```
3+5+7+2+6
```

However, if we can use SUM, we can put a single operator in front of the entire list of numbers, and skip typing the symbols in between.

```
(SUM 3 5 7 2 6)
```

Now We're on a Roll

How might we use SUM to work with lists of numbers? We might want to collect a series of numbers, and then add or average them. See Steve Tipps' April 1985 NLX column for several classroom ideas.

We have created an example to demonstrate how SUM might be used which involves a simulation. We created a procedure to simulate the roll of dice. We might use this procedure in a Logo game, or we might use it in a class on probability. The procedure looks like this.

```
TO ROLL
OP 1 + RANDOM 6
END
```

Every time that we type PRINT ROLL, Logo prints a number between 1 and 6, just as in the roll of a die.

```
?PRINT ROLL
2
?PRINT ROLL
5
```

A similar simulation and other projects for students can be found in *Nudges: Apple Logo Projects* and in *Nudges: IBM Logo Projects*, by Steve Tipps, Tim Riordon, and Glen Bull. These books of Logo projects are published by Holt, Rinehart and Winston.

If each of the numbers 1 through 6 came up an equal number of times, what would the average be? Well, the sum of the numbers 1 through 6 is 21.


```
?PRINT (SUM 1 2 3 4 5 6)
21
```

If you have six numbers which add up to 21, their average will be between 3 and 4.

```
?PRINT 21 / 6
3.5
```

This makes sense, because the middle of the number line is between 3 and 4.

```
1 2 3 4 5 6
```

What would we actually get if we throw our simulated dice five times?

```
?REPEAT 5 [ PRINT ROLL ]
2
5
6
3
4
```

To find the average, we need to sum the numbers, and divide by five.

```
?PRINT (SUM 2 5 6 3 4)
20
?PRINT 20 / 5
4
```

The average we get is close to, but not the same as, the number we expected. Would we get an average closer to 3.5 if we threw the dice more times? It's as easy to say "REPEAT 100" as it is to say "REPEAT 5." However, we don't want to retype all the numbers that are printed on the screen. Why not let Logo collect them for us?

Here's how to keep a record of the numbers. First, initialize a variable, which we'll call DATA.

```
?MAKE "DATA [ ]
```

DATA, as you may have recognized, starts out as a list that has nothing in it. Each time we throw the dice, we'll *put* the new number that we generate as the *last* entry in the list. (The command LPUT in ROLL.DATA stands for "last put".)

```
TO ROLL.DATA
MAKE "DATA LPUT ROLL :DATA
PRINT LAST :DATA
END
```

Let's try it out.

```
?ROLL.DATA
3
?PRINT :DATA
3
```

Let's throw the dice three more times, and add these numbers to the end of the list.

```
?REPEAT 3 [ ROLL.DATA ]
2
5
1
?PRINT :DATA
3 2 5 1
```

Once we develop the right tools, it's as easy to create a list that has the results of 100 rolls of the dice as it is to create one with five numbers. Now that we have a list with four numbers in it (3 2 5 1), we need to add the numbers together. One way to do this is to use the command SUM. The question is how can we make SUM use our list of numbers? Here's a tool, called ADD, which will do the trick.

```
TO ADD :LIST
OP RUN FPUT "( FPUT "SUM LPUT " ) :LIST
END
```

If you are using Terrapin Logo, it is necessary to create ADD in a slightly different way. Here's the short procedure that we promised you earlier in the column.

```
TO ADD :LIST
IF EMPTY? :LIST OP 0
OP (FIRST :LIST) + ADD BF :LIST
END
```

If you are using Version 1 of Terrapin Logo, you will also need the EMPTY? procedure.

```
TO EMPTY? :WORD.OR.LIST
OP ANYOF :WORD.OR.LIST = [ ] :WORD.OR.LIST = "
END
```

ADD adds a list of numbers:

```
?PRINT ADD [3 2 5 1]
11
```

Of course, since our numbers are already in the list :DATA, we don't have to type them out.

```
?PRINT ADD :DATA
11
```

Listful Thinking continued

To average the numbers in the list, add them and then divide by the number of items in the list.

```
TO AVERAGE :LIST
OP (ADD :LIST)/(COUNT :LIST)
END
```

If you are using Version 1 of Terrapin Logo, you will also need to type in a COUNT procedure before you use AVERAGE.

```
TO COUNT :WORD.OR.LIST
IF EMPTY? :WORD.OR.LIST OP 0
OP 1 + COUNT BF :WORD.OR.LIST
END
```

Now we can collect data in a list, and average it without retyping all the numbers.

```
?PRINT AVERAGE :DATA
2.75
```

You'll note that 2.75 is pretty far away from our expected average of 3.5 ... but of course we only threw the dice four times. Is there any relationship between how close we get to the expected value of 3.5 and the number of times we throw the dice?

Let's find out. First start out by creating an empty list again.

```
?MAKE "DATA []
```

Then roll the dice 100 times, and add each number you get to the end of the data list.

```
?REPEAT 100 [ ROLL.DATA ]
.
.
.
?PRINT AVERAGE :DATA
3.61
```

Here's what we got when we rolled the dice ten times, and calculated the average. (We did this four times.)

2.8 3.2 3.7 4.0

Then we rolled the dice 100 times, and calculated the average. Here's what we got the first four times we did this.

3.4 3.4 3.5 3.6

Rolling the dice 100 times usually gave us an average closer to 3.5 (the expected number) than just rolling the dice ten times. We thought we might get even closer if we rolled our simulated dice 1000 times, but we didn't want to stay up all night. If any readers would like to do this experiment, we would be interested in the results.

What does all this prove? Well, a gambler may get lucky a few times, but in the long run Las Vegas can count on the house advantage. In a more scientific vein, it also demonstrates some of the principles of sampling error. For example, how many people do you have to ask to find out who is going to be the next president?

We had fun doing this, and we'd like to encourage you to give it a try. However, we recognize that this play with numbers may leave some people cold (especially in March). Let's see what all this might have to do with social studies.

Perceive It or Not

Frequently, public policy is determined as much by perception as by fact. It often doesn't really matter what the facts are, it only matters what people *believe* they are. (Even if the preceding sentence isn't true, it doesn't matter as long as you *perceive* it to be true.)

You can conduct a poll about the perceptions of your own class. For example, how old do you suppose fourth-graders think the president is? (We don't recommend that you ask them how old they think *you* are!)

The following COLLECT.DATA procedure will allow you to poll your class, and find out the average of their guesses. Of course, some of your brighter students might ask whether the range of the numbers might be a better measure than the average. Or possibly the guess that occurs most often might be more interesting.

```
TO COLLECT.DATA
PRINT [ AFTER THE FINAL GUESS, ]
PRINT [ ENTER "Q" TO QUIT, ]
PRINT [ AND PRESS RETURN. ]
PRINT [ ]
PRINT [ AFTER EACH QUESTION, ]
PRINT [ ENTER A NUMBER, AND ]
PRINT [ THEN PRESS RETURN. ]
MAKE "DATA [ ]
COLLECT.LOOP
END
```

```
TO COLLECT.LOOP
PR [ HOW OLD DO YOU THINK THE PRESIDENT IS? ]
MAKE "NUMBER FIRST READLIST
IF NOT NUMBERP :NUMBER [ PRINT.AVG STOP ]
MAKE "DATA LPUT :NUMBER :DATA
COLLECT.LOOP
END
```

Listful Thinking continued

```
TO PRINT.AVG
PRINT []
PRINT [ THE AVERAGE OF ALL THE GUESSES IS:]
PRINT AVERAGE :DATA
END
```

If you are using Terrapin Logo, you will need to use the following version of COLLECT.LOOP.

```
TO COLLECT.LOOP
PRINT [ HOW OLD DO YOU THINK THE
PRESIDENT IS?]
MAKE *NUMBER FIRST REQUEST
IF NOT NUMBER? :NUMBER
PRINT.AVG STOP
MAKE *DATA LPUT :NUMBER :DATA
COLLECT.LOOP
END
```

Here's how the COLLECT.DATA PROCEDURE works.

```
?COLLECT.DATA
AFTER THE FINAL GUESS,
ENTER "Q" TO QUIT,
AND PRESS RETURN.
AFTER EACH QUESTION,
ENTER A NUMBER, AND
THEN PRESS RETURN.
```

HOW OLD DO YOU THINK THE PRESIDENT IS?

73
HOW OLD DO YOU THINK THE PRESIDENT IS?

78
HOW OLD DO YOU THINK THE PRESIDENT IS?

74
HOW OLD DO YOU THINK THE PRESIDENT IS?

Q
THE AVERAGE OF ALL THE GUESSES IS:
75

By changing the question in COLLECT.LOOP, you can use these procedures not only to conduct a poll about the perceived age of the president, but about any question that comes up in class. Of course, after the poll, the fun part is finding out what the answer really is!

(HAVING) SUM FUN

Polls and averages are used to get at many social issues. To take a mundane example, why are the chairs in your class the size that they are? Does the average height of a chair reflect the average height of a child? Of course, no matter what size chairs are, they will be too large for some children, and too small for others (as Goldilocks discovered). The question is how to minimize mismatches.

This is the heart of democracy, and comes up in a good many issues that go beyond the size of classroom chairs. However, it is apparent that even a simple issue such as this can be used to illustrate principles ranging from ergonomics to the democratic process. We'll be talking more about this next month.

In the meantime, some of you may have noticed the quotation at the beginning of the column. This quotation is from Artemus Lincoln, who teaches fifth grade at a nearby school...

Glen Bull is a professor in the University of Virginia's Curry School of Education, and teaches Logo courses at both the graduate and undergraduate level. His CompuServe ID is 72477,1637. Paula Cochran is finishing her doctorate at UVA's Curry School of Education. She is interested in Logo applications in language arts and speech-language pathology.

LogoWriter Announced

Logo Computer Systems Inc. has announced a new Logo product called *LogoWriter* in a series of advertisements in major computing magazines recently. *LogoWriter* is a combination of the LCSI Logo language and a programmable word processor, all in one application.

Using a piece of paper as a metaphor, *LogoWriter* permits both text and graphics (with up to four turtles) on the front side of the "paper" and the ability to define procedures on the back. The computer screen displays either the front or the back side of the "paper."

An especially interesting aspect of *LogoWriter* is LCSI's site license provision - permission to make unlimited copies! A school site can purchase *LogoWriter* for \$395, and receive versions for the Apple II computers and the IBM PC family of personal computers. Also included are activity cards, project books, and a teacher's manual. In addition to being able to provide *LogoWriter* copies to each student, the school site can purchase an extension of the license to permit their students to take their copies of *LogoWriter* home with them, providing that all copies are returned to the school site at the end of the term.

For a free information packet on *LogoWriter*, call 1-800-321-5646. New York residents call (212) 265-5646. Or write to Logo Computer Systems Inc., 555 West 57th Street, Suite 1236, New York, NY 10019.

TurtleTips

by Jane Toth
and Donna Lanyi

We've found that our students are "chomping at the bit" for some new challenges after many months of practicing primitive commands, the REPEAT statement, and circles and arcs. Now is the time to introduce procedure writing.

The Turtle Teacher

Students love to save their drawings to share with others. To do this, they need to write procedures in most cases. When writing procedures, students also need to become familiar with editing. We've found that our students readily grasp writing procedures but become bogged with editing. We know of only one solution: *practice!*

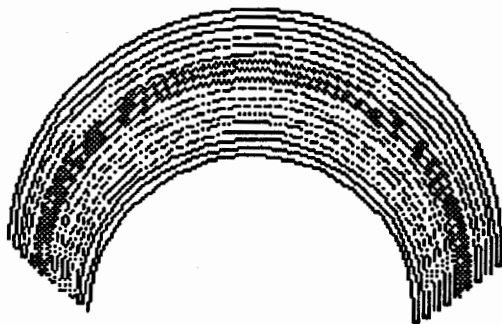
After introducing the concepts of procedures and editing to the class, we offer them plenty of opportunities for practice. We reinforce procedure writing with individualized packets of activities. Each packet contains a series of procedures that students can type in as models for correct procedural form.

Next, the beginnings of procedures that accompany a picture are given. Students are asked to complete the procedure. Of course, students are encouraged to try some of their own procedures that they have recorded in their computer notebooks.

We find that many students have difficulty learning the editing keystrokes. We've had our classes play EDIT (like BINGO) to help reinforce these concepts. Students write the CONTROL letters on their EDIT cards. The caller then says aloud the meanings of the editing keystrokes. Many similar games can be devised to help students tune these skills.

Once students become familiar with procedure writing and editing, they feel like they've "earned their wings." They are ready to be off and flying with their own ideas now.

Procedure of the Month



The pot of gold at the end of the rainbow can be your students' own creations. Take that pot of gold and utilize their ideas. Design a class display or newsletter featuring their projects to share with the school. If you are interested in a copy of a listing of our rainbow procedure, please send us a stamped self-addressed envelope.

Tell us about the interesting things you are doing with Logo in your school so we can share them with other NLX readers. Jane Toth and Donna Lanyi, Beall Avenue School, 716 Beall Avenue, Wooster, OH 44691, or CompuServe 72477,2623.

Jane Toth and Donna Lanyi use Logo in their elementary classrooms in the Wooster (OH) City Schools.

LIFT's

Teacher To Teacher A Review of New Logo Materials

by James Fry

This month's column has reviews on two different types of Logo publications. They should be of interest to both the beginning Logo user and teacher and to the advanced user or teacher looking for extended activities with Logo.

For the Beginning User or Teacher

Logo Lessons Volume 1 - A guided curriculum for educators developing math and computer skills, by John Glantz, published by Logo Lessons, PO Box 39, Liberty, PA 16930, \$29.95 (2 or more \$26.50 each), plus \$2.00 shipping and handling per manual. Returnable for a refund after 30 days if not satisfied.

Target Audience: Second grade to ninth grade teachers

Content: *Logo Lessons* is a guided manual for teachers who are looking for some direction and structure to help them teach Logo to their students. It covers the theory of Logo and a variety of off- and on-computer activities. *Logo Lessons* contains eight major lessons that the author states have been tested with second through ninth grade students. The teacher using these lessons gives one hour of lecture per week and has the students work either in class or during study or free time. The time required by fifth to seventh grade classes was about one month per lesson. The lessons are designed to build the students' abilities in computer literacy, math, and problem solving techniques. The lessons extend from the discovery of the basic turtle commands to multiple variables and repeats, along with team projects and advanced problem solving.

Teacher to Teacher continued

Format: *Logo Lessons* is set up in eight lessons with the same sequence for students and teachers to follow in each. A lesson requires between six and twelve hours to complete, depending on student age, computer use, and activities. Each lesson is organized around the following headings: materials for lesson, related topics, Logo topics, Logo concepts, classroom activities, computer activities, debugging and computer notes, bulletin board terms, thoughts about the lesson, mathematical concepts, activity centers, more Logo activities, and family oriented homework.

Logo Lessons also contains some "worksheets" that can be reproduced for classroom use. These are graphing sheets and some class and student note taking and organizational sheets. Video tapes and a training manual for each lesson will also be available to assist in teacher training in Logo.

Strengths: One thing struck me immediately: if you don't like *Logo Lessons*, you can return it within 30 days for a full refund. I would say that John Glantz has confidence in his work! The strengths of *Logo Lessons* are the variety of activities, with the on- and off-computer work for students. The structure that it has should also be a big help to beginning Logo teachers or teachers who have not really found a comfortable direction or sequence with the instruction of Logo. The availability of video tapes and a teacher training manual for each of the lessons should also be very valuable.

Comments: There is also a Volume II (geometric shapes, gears, and density) available and a volume III in the works that will cover list processing and clocks. NLX readers interested in more information should write to John Glantz, PO Box 39, Liberty, PA 16930.

Extended Logo Activities

Seven Microworlds for the Commodore 64, by Patrick W. Thompson, published by Cosine, Inc., PO Box 2017, West Lafayette, IN 47906.

Target Audience: First grade to university level students, depending on the microworld.

Content: I was able to look at five of the seven microworlds that Patrick W. Thompson has put together. They were titled:

Circuits - a microworld for logical inference,
 Num.aids - a number theoretic toolkit,
 Glueboxes - a microworld for arithmetic,
 Inside.Logo - a microworld for exploring the inner workings of Logo, and
 Integers - a microworld for integers and introductory algebra.

The author states that each has been used with students and teachers for at least one year before being published. The author also states:

"The genesis of each microworld has been that I've found a piece of mathematics that has been particularly troublesome for students to understand, so I wrote a program that they could use to "visualize the content" and wrote a set of problems that focused their attention on important structural features of the content. In other words, the driving force behind each microworld has been the issue of enhancing mathematical understanding in nontechnical and nontrivial ways."

After studying these microworlds, I believe that the author has accomplished this task.

Format: The microworlds are organized into small booklets of 5 to 10 pages each. Each booklet explains what the particular microworld has been designed to accomplish. Commands and their actions are given, along with examples, questions and discussions. They are short and concise and give students a good starting point for their explorations.

Strengths: It is refreshing to see some alternatives or extended activities for using Logo in the curriculum areas. I like the format of the short booklets on each of the microworlds.

Comments: Let's hope we see more of these types of microworlds being published. I really like small booklet format.

.....

What new Logo materials and books do you find useful in teaching? We invite you to send information to the Logo Information For Teachers (LIFT) group, PO Box 5396, Plymouth, MI 48170, or send electronic mail on CompuServe to 76317,565.

James Fry uses Logo with his Chapter 1 remedial mathematics students at Novi Community School, Novi, MI, and is a co-founder of the Logo Information For Teachers (LIFT) group.

Turtle Maze Book Available

Spizzirri Publishing Co., Inc., publishes a line of educational activity coloring books and mazes. Their book on turtles contains drawings of 29 different species of turtles and separate mazes based on the drawings. The price is right: 99¢. You will find many ideas for Logo projects and displays in this little book. For more information, write to Spizzirri Publishing Co., Inc., PO Box 664, Medinah, IL 60157, or call (312) 529-1181.

Q

and

A

by
Jim
McCauley

Q. I understand that Logo has "descended" from Lisp, the language used in artificial intelligence research. Why shouldn't we just start children in Lisp, rather than having them do Logo first?

A. This question occurred to the original Logo research team back in the mid-1960's when Logo was being designed. There are several very good reasons for having children start with Logo:

(1) Short programs are easier to read in Logo than similar programs in Lisp. Here is a pair of examples. Both are functions that accept two lists and return one list that contains the common elements of both. The first is in Lisp, the other in Logo.

```
(DEFUN UNION (LAMBDA (LST1 LST2)
  (COND ((NULL LST1) LST2)
        ((MEMBER (CAR LST1) LST2) (UNION (CDR
LST1) LST2))
        (CONS (CAR LST1) (UNION (CDR LST1) LST2))))))
```

```
TO UNION :LST1 :LST2
IF EMPTY? :LST1 [OP :LST2]
IF MEMBERP FIRST :LST1 :LST2 [OP UNION
BF :LST1 :LST2]
OP FPUT FIRST :LST1 UNION BF :LST1 :LST2
END
```

If you study these for a bit, you'll be able to map the Logo version onto the Lisp version, allowing for vocabulary differences and the heavy use of parentheses in Lisp. Actually, all those parentheses make very long Lisp programs *much easier* to read, but they are confusing and tedious for beginners. Also, the vocabulary of Logo is much closer to English.

(2) Besides being easier to read, most versions of Logo have much nicer facilities for beginners than do most versions of Lisp. The versions of Logo that are widely available have fairly powerful editors that are very easy to use, while most Lisps have outrageously powerful editors that can take quite a long time to learn. Also, I know of only one version of Lisp for microcomputers that includes turtle graphics.

(3) In all versions of Lisp, the only things that you can write are *functions* (what we call *operations* in Logo). A function is a program entity which always produces an output, as in this month's NLXual Challenges. For many of the things that we have children do first in

Logo (like turtle graphics), outputs are potentially confusing and not very useful. Logo gives us the capacity to write procedures that don't produce outputs. These are called commands. There is some controversy in the Logo community about the wisdom of this decision, since it can cause confusion when you start doing complicated things with the language. Of course, one option you have when your students hit those limits is to transfer them to Lisp. However, there is a tremendous amount that can be done with Logo before those limits are reached.

(4) Finally, Lisp was a language designed for general research work by professionals in artificial intelligence. Logo is a language designed for use by beginners of any age. Logo is easy to start with and has a tremendous amount of "growth room" before any serious limitations are reached. Although Lisp is a much easier computer language to learn than most, there is a significant threshold which must be overcome in learning it. But you can start using Logo immediately because it was specifically designed for that purpose.

In summary, then, Logo and Lisp share many similarities. Because of its low threshold, Logo is best suited for beginners. The powerful Lisp language is capable of carrying out the more complex projects of experienced programmers. The Logo - Lisp sequence is being explored by a few school systems already.

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Each month, I will answer selected questions in this column about Logo programming techniques and the thinking which leads to programming. If you have a question, send it to: Jim McCauley, NLX Q and A, 876 East 12th Avenue, #4, Eugene, OR 97401. Please enclose a stamped self-addressed envelope. You may also send questions to me at 70014,1136 on Compu-Serve's electronic mail system.

Jim McCauley is a graduate student at the University of Oregon, studying with David Moursund, and has written Logo articles for many national publications.

Logo on Television

Kentucky Educational Television (KET) has scheduled a rebroadcast of a segment of its "Educational Computing" series which features an interview with Joyce Tobias on Logo in the classroom and the quality of Logo teaching materials available. The segment, EC 315, can be viewed April 3 and 4 on public television. Consult your local station for broadcast time, or write KET, 600 Cooper Drive, Lexington, KY 40502 for more information. Telephone: (606) 233-3000. KET also has available a videocassette featuring all Logo broadcasts from the 1985-86 season.

Logo Notes

MACUL 86, a conference sponsored by the Michigan Association for Computer Users in Learning, will be held March 13 - 14 in Grand Rapids, MI. The program features a number of Logo presentations and related activities. This particular conference has received "high marks" for several years, and this year promises to be no exception. For more information, write to MACUL 86, PO Box 628, Westland, MI 48185, or call (313) 595-2493.

Discovery III: Training and Technology for the Disabled is a conference scheduled for March 10 - 12 in Milwaukee, WI. Listed on the program is a presentation entitled, "Using Logo and BASIC with Special Needs Children," by Deborah Jolly. For more information, write to Office of Continuing Education, University of Wisconsin - Stout, Menomonie, WI 54751, or call (800) 45-STOUT. (22-STOUT in WI)

The World Congress on Education and Technology will be held in Vancouver, British Columbia, May 22 - 25, 1986. The program lists presentations by nearly every top name in educational computing. For more information, write to Anne Marx, WCET, 1155 West 8th Ave., Vancouver, BC V6H 1C5 Canada, or call (604) 734-2721.

NECC 86, the National Educational Computing Conference, is scheduled for June 4 - 6 in San Diego, CA. Several Logo activities are scheduled. For a conference brochure, write to Jim Adams, ACM, 11 West 42nd Street, New York, NY 10036, or call (212) 869-7440.

IBM announces the publication of a series of IBM Logo manuals which are now available. A teacher's manual (\$55), student's manual (\$42), and a program diskette (\$11) may be ordered through your local IBM representative. *Logo Learner*, a special version of IBM Logo for the IBM PCjr computer, is also available.

Computeach is a computer curriculum for grades K - 6 developed by educators of the East Ramapo (NY) Central School District. Volume II of the series deals with Logo, and is being offered for sale to other educators. For more information, write to Diane Gess, East Ramapo Central School District, Office for Curriculum, 461 Viola Road, Spring Valley, NY 10977, or call (914) 356-4100, ext.292.

Chris Templar and her associates at Johnson Bible College in Knoxville, TN, have written a Commodore 64 BASIC program which converts Koala Pad picture files into a format which can be read by Commodore Logo. For a copy of the listing, send a stamped self-addressed envelope to Commodore Koala Listing, NLX, PO Box 5341, Charlottesville, VA 22905.

NLXual Challenges by Robs Muir

It's a Plot!

If we desire to form individuals capable of inventive thought and of helping the society of tomorrow to achieve progress, then it is clear that an education which is an active discovery of reality is superior to one that consists merely in providing the young with ready-made wills to will with and ready-made truths to know with.

Jean Piaget, 1975

When you tire of reading too many Logo books filled with cute little cartoon turtles and friendly bunnies, when all the Logo articles you read are concerned with "integrating Logo into the classroom experience," when Logo seems like nothing more than another (yawn) programming language, then it is time to go back and study the "classics" — the great works of the Logo's founders.

As Brian Harvey recently wrote, "Whatever happened to the revolution?" Have all the radicals been enfranchised by the system? We used to believe that the classroom would be integrated into the Logo experience, yet now we hear a different slogan. Today, every third-grade classroom lucky enough to have a computer offers a token lesson in Logo — just to show that they're progressive. But after the students' twenty minutes a week are up, it's back to the worksheets and dittos. This is not what the Logo forefathers and foremothers intended!

I recently dredged up Bob Lawler's "Designing Computer-Based Microworlds" (Byte Magazine, August, 1982), and on rereading this masterpiece, I remembered why I loved Logo from the start. Logo isn't a language; it's something more. It's an artifact of a community in love with learning.

The concept of microworld gets lost in the modern tempest of computer literacy. This month's challenge calls on you to build a world — simple, yet populated with rich ideas. A world infrequently explored by Logo's founders; the functional equivalent of Atlantis.

Mathematical functions return a value. Logo procedures (or primitives) that OUTPUT a value are termed "functions". The Logo primitive, SIN, is a simple example. Observe these numbers:

PRINT SIN -150

-0.5

PRINT SIN -90

-1

PRINT SIN -30

-0.5

PRINT SIN 0

0

Challenges continued

```
PRINT SIN 30
0.5
PRINT SIN 90
1
PRINT SIN 150
0.5
```

We could build our own functions in Logo:

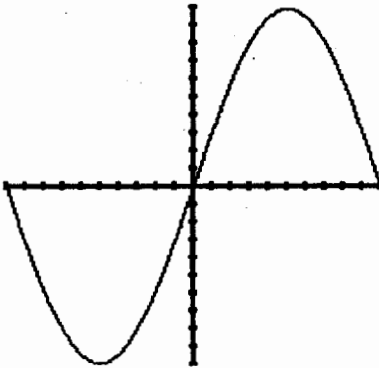
```
TO SQ :NUMBER
  OUPUT :NUMBER * :NUMBER
END
```

or, for the mathematically literate, $f(x) = 3x^2 + 4$ is equivalent to the Logo notation,

```
TO FUNCTION :X
  OP 3 * (SQ :X) + 4
END
```

The statement PRINT FUNCTION 3 will result in the number 31 being printed on the screen.

Using Logo's built-in Cartesian plotting tools, SETPOS (SETXY), SETX, SETY it is a simple matter to plot a function. All you have to do is run a range of X coordinates through your FUNCTION "machine" and have it return a set of Y coordinates for the turtle to move to. The SIN function above could look something like this:

**PlotWorld**

Your task is to build a general purpose plotting program that will allow you to plot any predefined function, such as — SIN, COS, or $f(x) = -.75 * (\text{sine}(x * 3))$. No fair looking at Lawler's previously cited article, or *Thinking with TLC Logo* (John Allen et al., Holt, Rinehart and Winston, 1984), Nancy Kovatch's "Functions of OUTPUT" (NLX, December, 1984), or *Apple Logo* (Drew Berentes, TAB Books, 1984). There are others; resist any temptation and build your own solution.

Bob Lawler states "The programming needed to make a Logo plotting subsystem is nearly trivial, but this is precisely the virtue of a powerful language." A further virtue of any programming language is its flexibility; there are several different approaches you might take in designing this plotting microworld.

This microworld could be given to fifth-graders for exploration. Why should ideas powerful enough for the ancient Greeks be denied our students simply because this "isn't covered until junior high school?" The Logo revolution hoped to transcend tradition by building new tools to think and explore with. Viva la revolucion!

Send your solution, along with a self-addressed stamped envelope to:

NLXual Challenges
Attn: Robs Muir
1688 Denver Avenue
Claremont, CA 91711

You may also send solutions and suggestions for additional challenges to me on CompuServe at 70357,3403.

We will compile several interesting solutions and redistribute them to all contributors.

Robs Muir is a teacher in the Claremont CA Unified School District and Claremont Graduate School.

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