Paper, Process, and Polyhedra: When the Product Isn't a Picture

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the computer, you may see notebooks full of ideas waiting to be tried when they next "boot up."

Children will soon discover there is no need to recreate previous work if it was saved as a procedure. Periodically saving work also reduces the risk of losing it through power outages, accidental erasure, or crashes. As awareness grows of these advantages, children choose procedure writing as the easy way to do a Logo project.

The product isn't as important as the process of problem solving. It's helpful for the teacher to review the process with students and to point out how techniques can be transferred from one problem to another. Such transference doesn't happen automatically. There are many ways to solve a problem depending on individual style and approach. Encourage students to recognize and share varying viewpoints for problem solving to build understanding of their own experience. This may help to increase the repertoire of thinking skills as well.

**Make the Computer Do the Work**

Students can use the computer to make their work easier. With LogoWriter, for example, commands can be repeated without retyping. Put the cursor on a line already typed and press RETURN. The turtle follows the same commands again! All of the commands typed since the program was booted are still there to be reused. Move the cursor with the "up" arrow so that the lines scroll down. It's easy to revise a line using <Delete> and inserting new elements.

To help younger children understand how they can recycle instructions, construct a monitor screen from paper or cardboard. Show the "front side" and "flip side" with a window below each to represent the command center. Write the command lines on a separate piece of paper to sandwich between front and flip sides. Pull it up and down in the command window, demonstrating that the commands disappear, yet are still available to use.

These techniques can also be used with Commodore Logo on those commands still visible on the text screen.

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**Logo LinX**

**by Judi Harris**

**Paper, Process, and Polyhedra: When the Product Isn't a Picture**

Did you ever catch a "culprit" with a folded paper "fortune teller" in your classroom? They are constructed (often when you are not looking) something like this:

Start with a square piece of paper, and fold the corners [A, B, C, D] to the center. This produces four more corners [E, F, G, H].

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Turn the paper over, and fold the four corners \([E, F, G, H]\) to the center, producing additional corners \([I, J, K, L]\). Turn the paper back over.

![Diagram of paper folding](image)

To make the paper figure, push the corners \([I, J, K, L]\) down, while opening up the corners \([A, B, C, D]\). Once constructed, different sections of the object are labeled with colors, names, numbers, and fortunes. The construction is then consulted (during recess time, you hope) in ritualized counting and question sequences, to reveal the future (or the secret admirers) of the answer-seeker. Traditionally, this folk craft is called "origami," and this particular object is the "salt cellar" or "pig's foot," but to many children, it is simply "awesome."

Add to this popular pastime the paper airplane and the inflatable folded paper box (which can be popped, if you dare, at just the right unsupervised moment,) and you have the basis for disciplinary action -- or a fascinating investigation into the properties of polyhedra, and the transformation of two-dimensional drawings into three-dimensional shapes.

**More on the Medium**

Does the medium determine the means? The method? The end? Fortunately, it doesn't have to. Logo need not be confined to exploration in two dimensions. In fact, the pictures that students create with Logo don’t have to be the endpoint of their investigations; they can be the planning models of later, off-computer construction.

Tests of spatial ability often include paper and pencil tasks which require the test taker to look at a drawing of a three-dimensional object, then choose the appropriate corresponding "unfolded" view. Since so much of required school work is two-dimensional, it is little wonder why these types of activities (presented, of course, in two dimensions) are difficult for children, while the construction of paper airplanes is not. Logo can help to link the dimensions experientially, if it is used as an architectural tool, or model-maker.

I recently worked with a sixth grade class that was immersed in a schoolwide interdisciplinary study called "Shapes, Patterns, and Structures," the brainchild of a most talented science coordinator, Mrs. Nancy-Lee Bergey. These otherwise sophisticated youngsters seemed to have trouble with every kindergartner's favorite activity: building. Since polyhedral constructions are the bases of many organic and inorganic structures (from sub-atomic to macro levels), we planned a sequence of geometric investigations that we hoped would provide the needed hands-on experience with three-dimensional building, at a level that would be cognitively sophisticated, tactily dependent and, of course, fun.

**The Third Dimension**

"But my II+5 won't run ExperLogo! How can we work in 3-d at my school?"

All the peripherals you need, really, are a printer and a polyhedra primer. The challenge to the class seemed simple.

"Use Logo to draw any three-dimensional figure, unfolded, in separate or connected pieces. You may use the wooden polyhedra models for inspiration, or you may design your own 3-d shapes. Then print your paper model, cut it out, and construct the shape with tape or glue. If the 3-d object needs adjustment, revise your Logo procedures and repeat the construction until it meets with your approval."

It was fascinating to watch the students cooperatively plan, draw, and dispute such attributes as relative side length, surface area, number of vertices -even volume. They hauled out the scrap paper, calculators, seldom-touched origami kits and paper-folding books to tackle this peculiar challenge. They constructed leaning pentahedra, tetrahedra with uncooperative edges, and partially-crushed cubes (hexahedra,) but also nearly perfect rhombicuboctahedra, truncated octahedra, and hexakaidecahedra, piece by piece.

Soon, the computer center and their classroom were decorated with polyhedra in all shapes, sizes, and stages of construction. The students first used Polyhedra Primer (Pearce & Pearce, Dale Seymour Publications, 1978) to identify the objects that they had already designed and assembled, then later as a source of more complicated three-dimensional construction challenges. The multisyllabic names caused many giggles, but also an interest in the relationships between individual syllable meanings and the geometric components of the constructions. Fortunately, the book shows the polyhedra in 3-d form, so that it was a source of inspirations, not solutions.

**Logo as Model Maker**

All of this activity was framed as a "planning stage" to the students. The next step in the project was to use the model(s) of their choice to help them to reconstruct similar polyhedra with balsa wood and glue or plastic straws with pins or string.

They then were able to manipulate the same edges and vertices of the constructions in three dimensions that they had just commanded the turtle to draw in two dimensions. This new perspective seemed to help them to focus on vertices as meeting-places of angles, which, in 3-d, didn't necessarily sum to the "total turtle trip" that they knew so well. It also seemed to create a heightened awareness of surface area and volume, as many of the groups decided to add tissue paper sides to their plastic straw polyhedra. Mrs. Bergey suggested that they test the strength of their constructions, and the generalizations that they derived about the relationships of structure to stability made the physicist in her proud.
When the End Is the Means

As usual, this adventure was quite instructive for me, too. So many of the turtle graphics projects that I suggested to my students had placed the picture as the final product; that structure had become almost implicit. How refreshing, then, to see the children using the Logo environment as an architectural tool, and a bridge between problem solving in two different physical realms!

Perhaps we need to devote as much thought and energy to the variety of means by which we suggest children solve problems as to the types of problems themselves. Logo itself certainly doesn't dictate a finite set of "appropriate" applications or exploratory methods. It is my hope that the projects described in this column each month have helped, and will continue to help you and your students expand and elaborate upon different methods and topics to investigate through Logo.

Since much of two- and three-dimensional geometry is credited to the ancient Greeks, I'll close with a bit of advice from one of their greatest teachers:

Do not then train [children] to learning by force and harshness; but direct them to it by what amuses their minds, so that you may be better able to discover with accuracy the peculiar bent of the genius of each.

--Plato

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MathWorlds

edited by A. J. (Sandy) Dawson

What Makes a Good Intervention?

The subtitle for this month's column is taken from a paper Liddy Nevile presented at the Second International Conference for Logo and Mathematics Education held this past July in London. Of course, there is not a single answer to Liddy's question. The three illustrations below, however, do provide some "fresh" replies to the question, and in so doing give a few suggestions of how to extend Logo to secondary and college level students.

Isometric Intervention

For the past few years, Liddy Nevile and her colleague, Colin Fox, have been exploring what they call "real micro-worlds for learning as opposed to those which merely enable users to do neat things." [3, p.201] They have worked at creating convenient and easily accessible means for Australian teachers to use Logo in new ways. They were concerned with creating Logo experiences which would assist students in acquiring an intuitive grasp of mathematical constructions.

Though mathematical constructions may seem trivial to some, large numbers of students seem unable to visualize and draw mathematical figures, thereby limiting their pursuit of mathematics. In response to this, Nevile and Fox designed a microworld for isometric drawing. "Operating it is simple, as there are, at first, six basic actions which generate the shapes." [3, p. 205]

In addition to helping students gain insight into three dimensional objects, Nevile hopes that the use by teachers of such microworlds in the secondary school "... which relate to topics... traditionally difficult to teach, these teachers might feel there will be legitimacy in using Logo for this purpose, and that... they will thus be initiated into Logo." [3, p.207] I hope so too.

Cycloidal Representations

A different kind of intervention was created by Uri Leron and Uzi Armon. They used an experience which many Israeli elementary school children have and transformed it for exploration by secondary and tertiary students. Children in elementary school use trundle wheels to measure distances. While doing this, if they watch carefully the path traced by the mark on the wheel, they would "see" a cycloid.

The question Leron and Armon focused on was "what path is traced by a point fixed on the circumference of a rolling circle?" The title of their paper at the Logo and Mathematics Education conference was, "How to Explain a Cycloid to a Turtle?"[1]

In addition to answering the question, Leron and Armon commented on the issue of local and intrinsic representations versus more standard global and extrinsic representations. Their main point in this regard is that they "...wish to study various representations and the relationships between them, rather than pledging allegiance to one. Understanding is best when we are at home with several representations and can choose at will the one which best suits the situation at hand.

"Of particular interest are methods of moving between standard and turtle representations. Using the powerful