Introducing Geometry and Algebra through Computer Programming

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While teaching a geometry unit to my Grade 5 and 6 class at Capitol Hill Elementary School, I decided to tie coordinate geometry to computer programming using high-resolution graphics on the Apple II+ microcomputer. I have a portion of my blackboard squared off with white lines so that I can easily number the axis for a grid for coordinate geometry and/or for the high-resolution graphics screen.

I began this particular introductory lesson on coordinate geometry by marking the grid in the same manner that is used for Apple high-resolution graphics. Students were told how to locate a point on the screen by starting at the upper left-hand corner, then going across, and then going down. A simple straight-line shape was then drawn on this grid (see Table 1).

Students were asked to identify the location of each point at the end of a straight line (see Table 2). Students had to locate the coordinates of the points from A to M in alphabetical order, and then end at B. Each point was written down on the blackboard. Where we had written the location of the coordinates, a space was left on the left-hand side so that we could add line numbers and key BASIC command words. After the location of the coordinate point was written on the blackboard, the word "TO" was written after it. This was followed by the coordinates of the point where the straight line ended. This procedure was continued until we returned to the starting point. To tie this into computer programming, the command "HPLOT" was placed in front of the line containing the coordinates of all the points. It was also necessary to add two BASIC commands to the program, "HGR" and "HCOLOR=3," before the location of the coordinate points. I then added line numbers to complete the required programming instructions. Following is the simple program that we ended up with in order to draw the rocket.

```
10 HGR
20 HCOLOR=3
30 HPLOT 10,0 TO 10,10 TO 15,15 TO 15,25 TO 20,30 TO 15,40 TO 15,35 TO 10,40 TO
         5,35 TO 5,40 TO 0,30 TO 5,25 TO 5,15 TO 10,10
40 END
```

To culminate this activity, the program was entered into the computer and run. The follow-up activity consisted of giving each student a sheet of graph paper (with the top and left-hand margin marked with numbers for plotting points in high-resolution graphics). Each student was asked to created a simple straight-line picture, and then write a computer program to draw this picture.

Those who completed the assignment were permitted to enter their program on the computer. To save time and reduce frustration, the "HELLO" program automatically loaded a "LINE EDITOR" program into the computer's memory. If corrections were required, the need to retype a complete line was eliminated. The students, once the program was entered into the computer, had instant feedback on their programs. If the computer drew what they had intended, they knew immediately that they were right. If the computer drew something else, they then had to go back to the graph paper and check the coordinates against what had been entered into the program. Students helped one another to do the checking. This cooperation resulted in students learning how to check the locations of the points and provided them with more time to enter their programs. Not only did students enter their programs during the math period, but they also asked for and received permission to enter their programs before school, at noon, or after school.

Having achieved this in a relatively short period of time, I thought that it would be interesting to teach students how to get their diagram to move either horizontally or vertically. This was done by going back to the grid on the blackboard (see Table 3). To get the rocket at the bottom of the screen, we assigned a variable to Y so that Y + 40 = 159. To get the rocket to move up, we decreased the value of Y.

In effect, what we were doing was placing a grid within a grid. This enabled students to plot various points using (X + the point on the second grid) as the distance over, and (Y + the point on the second grid) as the distance down. I felt that the students did not immediately grasp the reason why this was required, but they could follow the rules. Having the students watch the program with movement and asking them well-directed questions enabled the students to see what has happening.

This enabled us to use a subroutine alternately to draw, erase, move, redraw, erase, and so on, until the movement was complete. This movement was done through the use of a "FOR . . . NEXT . . . STEP" loop. At this time, the students were able to see what happened if we changed the value of either X or Y by a constant. The following is the program that we used to create movement:

```
10 HGR
20 X = 50
30 FOR Y = 1 TO 119 STEP -1
40 HCOLOR=3: GOSUB 20000
50 HCOLOR=0: GOSUB 20000
60 NEXT Y
70 HCOLOR=3: GOSUB 20000
80 GOTO 30000
20000 HPLOT X + 10, Y + 0 TO X + 10, Y +
          10 TO X + 15,Y + 15 TO X + 15,Y + 25 TO X + 20,Y + 30 TO X + 15,Y + 40
          TO X + 15,Y + 35 TO X + 10,Y + 40 TO X + 5,Y + 35 TO X + 5,Y + 40 TO X
          + 0,Y + 30 TO X + 5,Y + 25 TO X + 5,Y + 15 TO X + 10,Y + 10
20010 RETURN
30000 END
```

Coordinate geometry, algebra, number patterns, and computer programming had been introduced in a meaningful manner to students in the space of one school week. Students were highly motivated and delighted with the results.

Table 1

Grid showing a diagram of the rocket.

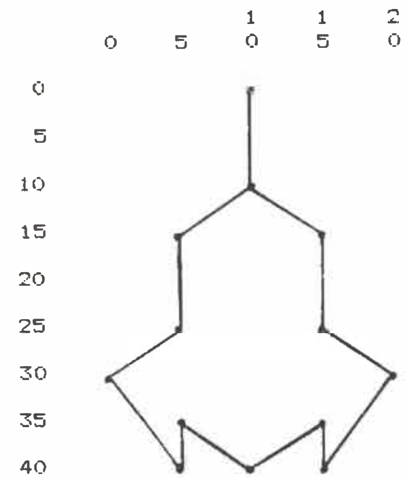

Table 2

Grid showing coordinate points of the rocket.

	0	5	10	15	20
●			A		
5					
10			B		
15		M		C	
20					
25		L		D	
30	K				E
35		I		G	
40		J	H	F	

Table 3

Grid showing coordinate points of a moveable rocket.

```
     0  5  0  .  .  .
0
5
10                 Y

                                    1   1   2
                X  +   0   5   0   5   0
                   0           A
                   5
                  10           B
                  15       M       C
                  20
                  25       L       D
                  30   K               E
                  35       I       G
                  40       J   H   F
```