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ABSTRACT

Four- and 5-year-olds' understanding of basic turtle graphics commands was examined before and after a hands-on, interactive problem-solving experience. Children (n=32) saw display screen events consisting of an initial turtle state, a command transformation, and the resulting turtle state. They were asked to give the command executed in each event. Most children systematically misunderstood some or all of the commands, and their misconceptions were in line with Piaget's characterization of young children's thinking. Contrary to anecdotal evidence, misconceptions were affected little by experience, feedback, and eventual success in solving turtle graphics problems. (Author/RH)

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Young Chidren's Misconceptions of Simple Turt, Graphics Commands

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Abstract

Four- and 5-year-olds' understanding of basic turtle graphics commands was examined before and after a hands-on, interactive problem-solving experience. Children saw display screen events consisting of an initial turtle state, a command transformation, and the resulting turtle state. They were asked to give the command executed in each event. Most children systematically misunderstood some or all of the commands, and their misconceptions were in line with Piaget's characterization of young children's thinking. Contrary to anecdotal evidence, misconceptions were affected little by experience, feedback, and eventual success in solving turtle graphics problems.

Young Children's Misconceptions of Simple Turtle Graphics Commands

Turtle graphics is a popular vehicle for introducing children to computer programming. Children combine simple graphics commands to get a display screen cursor called a turtle to draw designs on the screen. Anecdotal evidence suggests that young (i.e., preschool-aged) children are able to jump right into creating their own turtle designs. It is not clear, however, whether they actually understand how the turtle "works."

Piaget's theory of cognitive development provides good reason to question young children's understanding of turtle graphics commands. The basic commands, FORWARD (F), BACK (B), RIGHT (R), and LEFT (L) are transformations that result in changes in the turtle's state. F and B change position, in reciprocal ways, and leave orientation invariant. R and L change orientation, in reciprocal ways, and leave position invariant. A basic ability to relate states and transformations is thus central to understanding how the turtle "works." Since Piaget's theory characterizes young children as lacking in this ability, it seems important to take a close and careful look at the way they construe the basic turtle graphics commands.

The main purpose of their study was to examine young children's understanding of turtle graphics commands as transformations that connect turtle states, and characterize the nature of their misunderstanding. A second purpose was to see if hands-on, interactive problem-solving experience in turtle graphics would correct any initial misunderstanding.

Method

Turtle graphics environment. A highly simplified turtle graphics environment was created for the study. There were four possible turtle orientations, facing 0-, 90-, 180-, and 270-degrees, and four legal commands, F, B, R, and L. F and B moved the turtle a fixed distance forward and backward, respectively, and R and L rotated it 90 degrees clockwise and anti-clockwise, respectively.

Experimental task. The experimental task was administered before and after problem-solving experience. Children saw 16 events constructed from a 4 x 4, initial-orientation x command, factorial design. Each event consisted of an initial turtle state, a command transformation, and the resulting turtle state. Children were asked to name the command involved in each event (initial and final state information remained on the screen as memory aids). They completed two randomly ordered replications of the complete design.

Problem-solving experience. Children solved a series of simple turtle graphics problems (i.e., getting the turtle to a goal) requiring one, two, or three commands for solution. There were 40 different problems, and each as solved under two feedback conditions. One condition provided on-line feedback from the screen. Children gave a command, the turtle executed it, and the problem was either solved or the next command was given anc executed. The second condition provided delayed feedback from the screen. Commands were executed after the entire sequence was given. Children gave the command(s) they thought would solve the problem, and the turtle executed the given commands(s). They were asked to modify an incorrect solution, using information from the screen to figure out what went wrong. The turtle then executed the modified solution.

Procedure. In an initial session, children were introduced to the turtle graphics environment. The introduction included demonstration and explanation of each command, with the turtle beginning in each orientation. External aids (e.g., a cardboard turtle, a toy turtle, and having children "play turtle") were used to facilitate understanding. In subsequent sessions, children solved the turtle graphics problems. There were about three such sessions, spread out over about a two-week period. Each session began with a brief reintroduction, and ended with a few minutes of "free play." The experimental task was administered in the initial session (after the introduction), and again in a separate final session.

Subjects. Thirty-two 4- and 5-year-olds (mean age 5-1) participated in the study (25 completed the entire sequence of tasks). Prior to the initial session, none of the children had experience with turtle graphics or computer programming, although many had used computers to play games.

Results

Problem-solving. Two aspects of the problem-solving experience deserve mention here. First, children received clear annd frequent feedback about command effects. In the on-line feedback condition, children gave an average of 125 commands. Each time, they had an opportunity to see the turtle immediately execute the given command, and either do as they expected or not do as they expected. This alone would seem to be ample opportunity to correct any misconceptions.

The second aspect of interest is that children were successful in problem-solving. They eventually solved (i.e., eventually got the turtle to the goal) 99% of the problems with on-line feedback and 91% with delayed feedback. The question is whether children's hands-on, interactive, and successful use of commands to solve problems facilitated correct understanding of how the turtle "worked."

Correct performance. Table 1 shows percent correct performance before and after the problem-solving experience. Rotation trials involved execution of R or L, and displacement trials involved execution of F or B. Overall, children were not very good at naming (or inferring) command executions, especially executions of R or L. The problem-solving experience facilitated performance on displacement trials but, surprisingly, not on rotation trials.

<u>Rule classification</u>. Individual children's response patterns were classified by underlying rule as shown in Tables 2 and 3. The classification data capture the trends in the accuracy data. More importantly, they characterize the nature and illustrate the resilience of children's misconceptions of commands.

On rotation trials, the predominant rule was an incorrect End-State rule, both before and after the problem-solving experience. Children using this rule responded according to the turtle's end-state orientation. If the turtle ended facing 0-degrees, they thought F had been executed; if it ended facing 90-degrees, they thought R had been executed; and so forth.

On displacement trials, about a third of the children initially used an incorrect Direction rule. Children using this rule responded according to the direction of the turtle's movement on the screen. If the turtle moved in a 0-degree direction, they thought F had been executed; if it moved in a 90-degree direction, they thought R had been executed; and so forth. Another third of the children initially used a Correct rule, and a final third a combination of Direction and Correct rules. After the problem-solving experience, most children used a Correct rule.

Conclusions

Most children systematically misunderstood some or all of the basic turtle graphics commands, and their misconceptions were pretty much in line with Piaget's characterization of young children's thinking. When the turtle rotated, children tended to focus on the final turtle state (i.e., orientation), and not on the rotation transformation itself. Even when they seemed to know that F and B produced displacement transformations, they still thought these commands were involved in certain rotation events. When the turtle changed location, children seemed to attend to the displacement transformation itself. Initially, however, they often viewed the displacement with reference to themselves or the screen, and not with reference to the turtle.

That young children initially misconstrue the basic turtle commands is interesting, but not particularly alarming. What is alarming, however, is the small effect of hands-on, interactive problem-solving experience on these misconceptions. Indeed, children's eventual success in using the commands to solve problems did not reflect conceptual change, at least not to a great extent. This suggests that young children's entry into turtle graphics will not be as easy and spontaneous as suggested by anecdotal evidence, and hoped for by educators.

Table 1

Percent Correct

Trial Type	Time	
	Before	After
Rotation	26	36
Displacement	56	74

Table 2

Rule Usage on Rotation Trials

	After				
Before	Random	End-State	Combination	Correct	TOTAL
Random	-	5	-	4	9
End-State	-	11	1	4	16
Combination	-	-	-	-	-
Correct	-	-	-	-	-
TOTAL	-	16	1	8	

If the turtle ended facing 0-degrees, say F occurred; 90-degrees, say R occurred; 180-degrees, say B occurred; 270-degrees, say L occurred.

A combination of End-State and Correct rules.

Always say R or L occurred.

Table 3

Rule Usage on Displacement Trials

	After				
Before	Random	Direction	Combination	Correct	TOTAL
Random	-	-	-	1	1
Direction	-	2	1	5	8
Combination	2	-	1	5	8
Correct	-	-	1	7	8
TOTAL	2	2	3	18	

If the turtle moved in a 0-degree direction, say F occurred; 90-degree direction, say R occurred; 180-degree direction, say B occurred; 270-degree direction, say L occurred.

A combination of Direction and Correct rules.

Always say F or B occurred.