

# Comparison of Instructional Materials for Solving a Complex Task: The Rubik's Cube

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Funding Provided by the Bugold Fellowship



## Step-By-Step Method

vs.

## Heuristic Method

**STEP 1a: Position White-Red Edge**

BEFORE

AFTER

The Step-by-Step directions were laid out in a way that as long as students could match their cube to one of the "before" pictures, they should be able to complete the step by simply following the directions below. The advantage to this method is that each step is clearly defined. The disadvantage, we believe, is that students will not learn from the steps, but will instead simply follow directions.

**Abstract**

Research participants were given two sets of written directions for solving Rubik's Cubes (Step-By-Step and Heuristic). Participants were from four eighth-grade classrooms, with each class being given an even split of the two sets of directions. As students completed steps they raised their hands and the research staff initialed a record sheet. The results showed that students were able to complete more of the Rubik's Cube using Step-By-Step directions.

**Research Questions**

- Do eighth-grade students complete more blocks of a Rubik's Cube using Step-By-Step instructions or Heuristic instructions?
- Is there improvement using Step-By-Step instructions sixteen days after initial introduction?
- Is there improvement using Heuristic instructions sixteen days after initial introduction?

**STEP 1: Solve White-Red-Blue Corner**

BEFORE

Get to "AFTER" by any means possible

AFTER

The Heuristic directions were more goal orientated. The directions show a picture of what the cube should look like by the end of the step but did not give explicit directions for reaching the goal (until later steps). The directions were to get the cube to look like that, in whatever way possible. The advantages to this method is it appears to be more memorable because the things that are done to the cube are a person's own. The main disadvantage is, of course, there is not a set way of solving each step, which frustrated some of the students.

**Process**

**DAY 1**

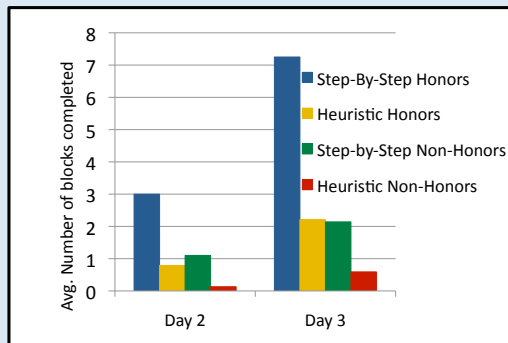
- Students were introduced to the Rubik's Cube.
- Students were shown the general format of instructions.
- Students were shown notation used for instructions (F=Front, U=Upper, R=Right, L=Left, B=Back, D=Down, ' =Inverse)
- Students practiced working with the Rubik's Cube and notation.

**DAY 2 (next day)**

- At random, students were either given Packet A (Step-By-Step) or Packet B (Heuristic).
- Students completed demographic data and were given the entire class period to work on completing steps in packet. No further instruction was given.
- Upon completion of a step, students would raise their hand to have a researcher mark a record sheet.

**DAY 3 (sixteen days later)**

- Students were given the same packet as they had on Day 2
- The entire process from Day 2 was repeated.



**Results**

- Paired T-test shows that Honors students had significant growth ( $p=0.006$ ) from Day 2 to Day 3 with the Step-By-Step Method, but did not have significant growth ( $p=0.158$ ) with the Heuristic Method.
- Paired T-test shows that non-Honors students had significant growth ( $p=0.006$ ) from Day 2 to Day 3 with the Step-By-Step Method, but did not have significant growth ( $p=0.107$ ) with the Heuristic Method.
- Independent T-test shows that Honors students, on Day 2, completed more blocks using the Step-By-Step Method vs. the Heuristic Method ( $p=0.024$ ).
- Independent T-test shows that Honors students, on Day 3, completed more blocks using the Step-By-Step Method vs. the Heuristic Method ( $p=0.025$ ).
- Independent T-test shows that non-Honors students, on Day 2, completed more blocks using the Step-By-Step Method vs. the Heuristic Method ( $p=0.00$ ).
- Independent T-test shows that non-Honors students, on Day 3, completed more blocks using the Step-By-Step Method vs. the Heuristic Method ( $p=0.007$ ).

**Data Analysis**

After data was gathered, steps completed from both methods were converted to the number of blocks completed. If you analyze a Rubik's Cube, you can see that there are 27 blocks. Six of those blocks are center pieces, and never move. One of those blocks is the center cube which is not visible. Therefore, instead of comparing the number of step completed, we translated the steps to blocks completed, which gave us a more comparable metric.

One-way ANOVA with Tukey Post-Hoc test to see if classes were different. Day 2, Honors class were significantly different at the 0.05 level from one class, but Day 3 the Honors class was statistically different from all other classes at the 0.05 level. For this reason, the analysis will separate the Honors class and pool the remaining classes for analysis.

ANOVA for Blocks Completed between Classes

Source	df	F	p
Day 2	3	3.530*	0.018
Within Group Error	95	(3.001)	
Day 3	3	5.386*	0.002
Within Group Error	98	(14.759)	

Note: Values enclosed in parentheses represent mean square errors.  
\* $p < 0.05$

**Conclusions**

- Our research found that students completed more blocks of the Rubik's Cube using the Step-By-Step Method than the Heuristic Method. Possible explanations include:
  - Eighth-grade students may think more procedurally.
  - Heuristic methods rely on greater prior knowledge than Step-By-Step procedures.
  - The Step-By-Step Method is broken down into smaller steps than the Heuristic Method.
- From Day 2 to Day 3 all groups improved. This is most likely because students were more comfortable with the instructional layout.
- The Honors Class on the whole was much more successful at solving the Rubik's Cube. This could be a result of Honors students having a higher proficiency with Step-By-Step instructions.

**Limitations:**

- The Step-By-Step Method was broken into sub-steps, giving us more checkpoints. The Heuristic model was not broken down as much. This could cause some slight error in the study.
- More pilot testing was done on the Step-by-Step directions, 5 pilot tests, versus 2 pilot tests for the Heuristic directions.