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

Mark D. Lefeber, B.M.E. student
lefebermd@uwec.edu

Chris S. Hlas, Ph.D.
hlascs@uwec.edu

University of Wisconsin-Eau Claire
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Step-By-Step Method vs. Heuristic Method

**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 initiated 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**
1. Do eighth-grade students complete more blocks of a Rubik’s Cube using Step-By-Step instructions or Heuristic instructions?
2. Is there improvement using Step-By-Step instructions sixteen days after initial introduction?
3. Is there improvement using Heuristic instructions sixteen days after initial introduction?

**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, R=Right, B=Back, L=Left, U=Upper, D=Dark, *inverses)*
- 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**
- Pair 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.
- Independent 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 non-Honors students, on Day 2, 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 3, 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).

**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.

**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 pieces is the center piece and 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 was 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**

<table>
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<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 2</td>
<td>3</td>
<td>3.530*</td>
<td>(3.001)</td>
<td>0.018</td>
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</tr>
<tr>
<td>Within Group Error</td>
<td>95</td>
<td>(3.001)</td>
<td>(3.001)</td>
<td>(3.001)</td>
<td></td>
</tr>
<tr>
<td>Day 3</td>
<td>3</td>
<td>5.386*</td>
<td>(14.759)</td>
<td>0.002</td>
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<tr>
<td>Within Group Error</td>
<td>98</td>
<td>(14.759)</td>
<td>(14.759)</td>
<td>(14.759)</td>
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</tr>
</tbody>
</table>

Note: values enclosed in parentheses represent root mean square errors.

* p<0.05

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