Using Variation and Comparison to Help Students Recognize Structural Features of Statistics Word Problems
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Background & Hypotheses
A common problem in statistics instruction is that students learn to carry out various hypothesis tests, but are unable to determine when to use them. This is a problem of categorization; students do not recognize what features signal problems of the same type. Category learning is improved through both comparison and similarity of surface features, both of which highlight alignable differences and support schema abstraction (Braithwaite & Goldstone, 2015; Gentner & Smith, 2013).

Limited recent work (Quilici & Mayer, 2002; Yan & Lavigne, 2014) has shown that teaching students about structural features of statistics word problems improved their ability to sort those problems according to the appropriate hypothesis test. Our study aims to expand on this work by manipulating the degree to which students engage in comparison between problems, as well as the surface similarity of the problems being compared.

Hypotheses:
1. Direct side-by-side comparison should improve category learning more than sequential problem presentation.
2. Similar surface features should facilitate category learning by highlighting structural differences (i.e. alignable differences) between the categories.
3. Comparison and surface similarity will produce additive gains (greatest benefit for simultaneous & similar features).

Design & Procedure
Sequential Presentation
- Pretest: 12 multiple-choice questions
- Correlation word problem, feature table, & graphic organizer
- Paired-samples t-test word problem, feature table, & graphic organizer
- Compare all 3 hypothesis tests (3 pair-wise comparisons)
- Posttest (counterbalanced order)
  - Sorting Task A: near transfer (finesse context)
  - Sorting Task B: far transfer (varied contexts)
  - Demographic questionnaire

Simultaneous Presentation
- Compare all 3 word problems (3 pair-wise comparisons)
- Simultaneous presentation of feature tables and graphic organizers for all 3 word problems
- Independent-samples t-test word problem, feature table, & graphic organizer
- Compare all 3 hypothesis tests (3 pair-wise comparisons)

Results
N=140; 33-38 per condition

<table>
<thead>
<tr>
<th></th>
<th>Pretest Accuracy</th>
<th>Posttest Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proportion: Correct</td>
<td>Simultaneous</td>
</tr>
<tr>
<td></td>
<td>Similar</td>
<td>Varied</td>
</tr>
</tbody>
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Comparison Style
- Significant interaction between Presentation Style and Surface Features for normalized gain (F(1,136)=4.10, p<0.05). No differences between conditions at posttest (Interaction: F(1,136)=1.19, p=0.277).

Discussion
Finding a cross-over interaction with no main effects suggests that different surface features are beneficial under different circumstances.

All conditions involved a great deal of comparison, but the conditions of those comparisons differed with respect to working memory demands.

Sequential presentation involves higher working memory load to remember and compare problem features from previous pages, so similar surface features may offload some effort of remembering specific problem features.

Simultaneous presentation involves lower working memory load because all of the content to be compared is visible simultaneously, but maximally similar problems did not produce as much learning as varied surface features.

It’s possible that varied surface features produced more learning because they were more difficult to compare; may have lead to greater schema abstraction because of desirable difficulties in processing alignable differences.

Future Directions
Expanding set of hypothesis tests to be explored to include ANOVA and linear regression.

Analysis of common errors students make when categorizing problems, and surface features commonly associated with those errors.

Teasing apart the role of comparison by varying the degree to which students are explicitly instructed to compare problems and/or solutions to those problems.

Teaching problem categorization to completely naïve students, rather than those who have already taken a statistics course.

References