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Learning Statistics: The Use of Conceptual Equations and Overviews to Aid Transfer

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Learners can carry out new procedures or solve new problems that are quite similar to those on which they were trained, but they have difficulty when the novel cases involve more than minor changes from what they had previously studied. This transfer difficulty seems to stem from a tendency by many learners to memorize the steps of how equations are filled out rather than learning the deeper, conceptual knowledge that is implicit in the details. One type of knowledge structure that appears to aid procedural generalization is one organized by subgoals (Catrambone, 1998). A subgoal represents a meaningful conceptual piece of an overall solution procedure and can serve as a guide to which part of a previously-learned solution procedure needs to be modified for a novel problem.

In the domain of mathematical problem solving there are often "computationally-friendly" solution approaches in which multiple solution steps are collapsed into a single formula. These formulas allow for the easy calculation of the solution by simply inserting the correct values into the formula. A major drawback of this approach is that it is restricted to solving a narrow range of problems that fall into predefined problem categories corresponding to solution formulas.

A good example of such a contrast is the process of calculating sum of squared deviation scores (SS) for the variance terms in t-tests and analyses of variance (ANOVAs). The conceptual formula for SS in a t-test, $\sum (X - \overline{X})^2$ translates directly into the sum of squared deviations. This clearly captures how the variance term measures the amount of spread about the mean. In contrast, the computational formula for SS, $\sum X^2 - {(\sum X)^2}/{N}$ permits the learner to calculate SS directly from raw scores which can lead to more efficient calculations, however, the computational formula conceals the notion of spread.

We were also interested in the relative effectiveness of overview information presented to learners either before they studied an example or after they studied an example. Overview information offered as a pre-instructional aid might, like advance organizers, provide an organizing cognitive structure for receiving new material (Ausubel, 1968). However, a pre-example overview runs the risk of appearing too abstract and non-contextualized. A post-example overview might supplement or reinforce what was illustrated in the examples, thereby facilitating the integration and application of recently acquired procedural knowledge.

Procedure and Hypothesis

Participants (N = 112) studied a t-test example and a two-group ANOVA example that used either a conceptual or computational approach. Overview information either preceded or followed each example. Participants then solved two near transfer problems (a t-test problem and a two-group ANOVA problem) and a far transfer problem (a three-group ANOVA problem that required an adaptation of how variance was calculated). We hypothesized that consistent with a subgoal-learning approach, learners who studied examples with conceptually-oriented equations would transfer more successfully to novel problems compared to learners who studied examples using computationally-oriented equations.

Results and Discussion

The conceptual group outperformed the computational group on the 2-group ANOVA problem; this is a bit surprising because all participants studied a 2-group ANOVA example. One possible explanation for this finding is that the conceptual equations are easier to implement and to check for errors. The conceptual group was also more successful on the 3-group ANOVA problem which is consistent with the hypothesis that these participants were better able to modify the equation.

There was no effect due to the position of the overview. This suggests several possibilities including: the material simply was not very effective; positioning of such material does not matter for learning in this domain; learners may have been less inclined to pay attention to it because the overview material essentially recapitulates the information provided in the examples (with a bit of elaboration) but without numbers.

Brief References and Acknowledgments

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