Computational Accuracy and Conceptual Understanding of Statistics: Effects of Thinking Before Plugging and Chugging

David L. Trumpower (trumpower@marshall.edu)
Department of Psychology, Marshall University
One John Marshall Drive, Huntington, WV 25755 USA

Introduction

Mathematics in general and statistics in particular are notoriously difficult topics for many students. Part of the difficulty may be that students view unfamiliar equations and procedures as being extremely complex and, as a result, focus on learning the computational procedures involved in solving problems at the expense of developing a conceptual understanding of the principles which underlie those procedures. One remedy for this situation is to present conceptual, rather than computational, equations to students. Atkinson, Catrambone, and Merrill (2003) found that learners who were trained to perform t-tests using conceptual equations were better able to transfer their knowledge to solve Analysis of Variance (ANOVA) problems than were learners trained to solve t-tests using computational equations.

Even students who posses both computational skill and conceptual knowledge, however, often fail to make use of their conceptual knowledge (Trumpower, 2003). Anecdotal evidence is provided by students who are able to perform a particular statistical computation accurately, but who then fail to draw accurate conclusions based on the computation. It is possible that this situation is caused by students' tendencies to solve statistics problems by immediately looking for appropriate equations and then plugging numbers into those equations (i.e., "plugging and chugging") before thinking about what the equations and numbers actually represent. If so, then forcing learners to answer some simple conceptual questions before performing computations may create links between conceptual and procedural knowledge, and thus allow them to draw more accurate conclusions. This hypothesis was tested in the present study.

Method

Twenty-eight undergraduate psychology students at Marshall University who had not previously taken any statistics courses served as participants. All participants were first asked to study a booklet that described a procedure for performing an independent-groups t-test and provided a solved example. Participants were then asked to perform 2 independent-groups t-tests and to state their conclusions based on the results of the tests. Half of the participants were randomly assigned to a conceptual condition in which they were asked to answer a series of conceptual questions before performing the t-tests. The other half were assigned to a procedural condition in which they performed both t-tests before answering the conceptual questions.

Results

Participants' computations and conclusions for the two t-tests were scored for accuracy. Also the percentage of conceptual questions answered correctly was determined for each participant. A one-way ANOVA revealed no significant difference between the percentage of conceptual questions answered correctly by participants in the conceptual and procedural conditions, $F<1$. A 2 Condition (conceptual, procedural) x 2 Assessment Type (computations, conclusions) mixed factorial ANOVA with repeated measures on the second factor revealed a significant main effect of Assessment Type, $F(1, 26) = 58.40$, $p < .001$, that was qualified by a significant Condition by Problem Type interaction, $F(1, 26) = 8.03$, $p < .01$. Participants in the procedural condition made more accurate computations than participants in the conceptual condition, whereas participants in the conceptual condition drew more accurate conclusions than participants in the procedural condition.

Discussion

Although participants in both conditions were equally capable of answering simple conceptual questions, those who answered them before performing computations were better able to draw accurate conclusions from the computations than those who performed the computations first. However, answering the conceptual questions first appears to have interfered with performing the computations. This latter finding may have been due to increased cognitive load of participants in the conceptual condition, as they may have been thinking about implications of the conceptual questions while performing computations.

References

Atkinson, R. K., Catrambone, R., & Merrill, M. M. (2003). Aiding transfer in statistics: Examining the use of conceptually oriented equations and elaborations during subgoal learning. *Journal of Educational Psychology, 95,* 762-773.

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