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Categorizing Physics Problems

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Experts, within their field of expertise, perceive and categorize problems differently than novices. For example, Chi, Feltovich, and Glaser (1981) argued that novices represented physics problems primarily on the basis of surface features, such as the angle at which the plane is inclined with respect to the horizontal. Experts, on the other hand, represented the same problems around basic laws of physics, such as principles of mechanics, conservation of energy, and Newton's laws of force. The goal of the present study was to investigate the efficacy of two methods to get novices to categorize physics problems along the same dimensions as experts.

The rationale for this study was derived from a hypothesis generated by Brooks (1978) and Markman (1989). The hypothesis was that for simple, well-defined concepts, such as a square, people would represent these concepts in terms of abstract defining rules. However, for more complex concepts, a person's knowledge is more likely to be exemplar-based rather than based on defining rules. That is, people memorize exemplars of a given category rather than a set of defining features. The person could then reason about the category by comparing new members to familiar ones. Given that physics problems are examples of an ill-defined categories, we reasoned that exemplar-based training for representing physics problems would facilitate the acquisition of the more abstract representational model than a definitional-based approach.

Thus, in this study we asked subjects to sort a set of physics problems into three different groups corresponding to problems that primarily relate to conservation of energy, Newton's second law, and conservation of momentum. Two different types of training conditions were provided. In the definitional training condition, subjects were provided with a short description of the defining features for each of these types of problems and were asked to sort the problems into the relevant groups. In the exemplar training group, subjects were told that there were three physicists and each liked to work on a specific type of problem. Subjects were asked to figure out which problems each physicist liked to work on. This essentially put the subjects into a guessing mode and a paired-associate task where the subjects had to memorize which problem went with which scientist. Although the subjects were not informed, the first physicist liked conservation of energy problems, the second, problems involving Newton's second law, and the third, problems illustrating conservation of momentum. Thus, both groups were required to sort the problems in

the identical way. Fifteen problems were presented; 5 related to each category.

After subjects in both training groups met the sorting criterion of 2 successful sorting trials for all 15 problems, they were then given a second sorting task to do. The definitional group was asked to continue what they had done previously with a new set of problems. The exemplar group was now given the definitions of the three groups and asked to sort the problems by definition. Thus, for this second sort, both groups were given the same problems to sort with the same set of instructions. A third group of subjects (no training) were just given the second sort trial with definitions. Once again, all subjects sorted until they reached the criteria of two successful sorting trials. Presentation of the problems and the recording of the data were controlled by a HyperCard program.

Subjects. The subjects in the study were 48 high school students who were in their second year of physics study.

Results. The two training groups significantly differed in the number of trials required to reach criterion, with subjects in the exemplar condition requiring fewer number of trials (mean = 6.9) than those given definitions (7.9). These results argue that the categorization task by definitions was indeed difficult and that it was easier to do by rote memory than through feature detection. For the second sorting task, where everyone had to sort by definitions, significant differences between the three groups were observed. The no training group required a mean of 8.2 trials to reach criterion, the definitional group required a mean of 6.8 trials and the exemplar group required a mean of 5.9 trials.

Discussion. The results from this study supported Brooks' hypothesis that categorization of these ill-defined categories are best acquired through exemplar-based practice.

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