TEACHING PROBLEM SOLVING: AN ATI STUDY OF THE EFFECTS OF TEACHING ALGORITHMIC AND HEURISTIC SOLUTION METHODS

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ABSTRACT

This paper begins by characterizing typical training programs on “learning to think,” in terms of: their breadth, generality and specificity; the types of tasks and solution methods; and the guidance to students (assigning them to alternative programs; registering and reacting to their mistakes, requests for help, etc.). The paper then outlines some strengths and weaknesses of past research and sets out criteria appropriate for an aptitude–treatment interaction (ATI) study of the relationship between tasks, training methods and student attributes. Finally, an account is given of exemplary ATI experiments, administered via a computer, on the immediate and delayed effects of teaching algorithmic and heuristic solution methods. The tasks involve inductive reasoning (the extrapolation of number series) and deductive reasoning (the evaluation of syllogisms).

The question of how to teach problem solving can only be answered by taking into account: (a) the kind of problem to be solved, (b) the desired outcome of the training program (e.g., reaching a certain level of performance with one type of instructional problem, or transfer to problems of different kinds), and (c) relevant personality variables.

In a broader framework, the question of teaching problem solving becomes a question of “learning to think” or “learning to reason.”

Within existing training programs on “learning to think,” three dimensions can be distinguished:
(1) molar-molecular,
(2) degree of specificity of the operation prescriptions, and

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(3) degree of control of the execution of the operation prescriptions.

The first dimension, the molar-molecular one, indicates the breadth and generality of the thinking capacities to be trained. The work of Lompscher (1975) in Eastern Germany (GDR) is an example of a training program on a molar level. In his research the development of mental abilities (geistige Fähigkeiten) developing from mental activities (geistige Tätigkeiten) is emphasized. His approach is characterized by the development of mental abilities through a sensitive choice of school subject matter. Such training programs extend over a number of years of the elementary school. This molar approach is attuned to the rather general cognitive abilities being strived for: abstracting, generalizing, differentiating, distinguishing between part and whole, etc.

An example of the molecular approach in teaching problem solving can be found in the work of Landa (1969, 1976). According to Landa the training of abilities like abstracting, generalizing, etc., is not fruitful. The operations are too general; each representing a set of operations. To be trainable, operations need to be sufficiently specific, because only then is steering of the solution behavior (the operations) possible.

This specificity is the second dimension on which training programs for problem solving can be classified. The decision as to degree of strictness, extensiveness, and specificity, by which the solution process has to be prescribed, is one of the dilemmas with which one is confronted in designing training programs to teach problem solving.

One solution is to confine oneself to what Dörner (1978) terms practice training. In this approach the student is confronted with certain problem-types without any indication of how to set about them. This is the most primitive and restricted form of "teaching to think." It is hoped that solely by confrontation with cognitive tasks, the process of problem solving will develop. The idea behind this approach is that the heuristic structure (the total set of available solution methods) - distinguished by Dörner from the epistemic (knowledge) structure - is not completely rigid, so that a variation of solution methods is possible. By reinforcing the correct, effective variation, behavior becomes shaped and the heuristic structure extended.

At the other extreme of the specificity dimension is the approach of prescribing exhaustively the necessary operations and their sequencing. This is called the algorithmic method.

Between the mentioned extremes there are approaches which involve degrees of steering of the solution behavior with discovery of some of the necessary operations being left to the pupil. These are called heuristic methods.

Training programs on problem solving may also differ on a third dimension - the extent to which they control the thinking process of the pupil. By control is not meant the steering of the solution process but the registration of the student's actions (mistakes of different types, asking for help, etc.) and the adequate reaction to these actions.