ABSTRACT CARD TASKS FOR USE IN PROBLEM SOLVING RESEARCH

JOSEPH M. SCANDURA
State University of New York at Buffalo

THE MATERIALS used to study problem solving have varied so greatly (5) that it has been difficult to collate many of the findings. It has been especially difficult to bridge the vast chasm between problem solving research in the classroom and in the laboratory. Much of this difficulty stems from a scarcity of suitable research materials.

The purpose of this article is to present some abstract card material which has been found applicable, at most educational levels, to research in both the classroom and the laboratory (6, 7). This material was designed to meet the following criteria.

1. Prior knowledge and problem solving sophistication should have a minimal effect on learning.

2. It should be possible to construct a wide variety of related multi-stage problems.

CARD MATERIAL

The following material is related to the card tasks used in Bruner, Goodnow, and Austin's (1) study of concept attainment. Sixty-four cards, each having two objects, are used. Each object is either large or small, black or white, and a circle or a triangle. Twelve symbols are introduced: L1, S1, B1, W1, C1, T1, L2, S2, B2, W2, C2, T2. Respectively, they represent: first object is large, ..., first object is black, ..., first object is a circle, ..., second object is small, ..., second object is white, ..., second object is a triangle, .... Subsets of this set of symbols are given multiple meaning. For example, the subset [S1 C1 B2], stands for the first object is a small circle and the second object if black.

Relationships between subsets and a card are readily specified, by attaching to the card one of the labels; +all, -all, +1, -1, ..., -6. The label +all was used to specify the relationship "all symbols in a subset agree with the card-properties."

The other labels, respectively, specified: none of the symbols agree, exactly one symbol agrees, exactly one does not agree, ..., exactly six do not agree.

By labeling a card in this manner, it is possible to determine whether a given subset is associated (i.e., has the specified relationship) with it. Before going on, the reader should satisfy himself that the subsets to the right of each labeled card in Figure 1 are associated with the card in the manner indicated.

Since a subset may "go" with several cards simultaneously, it is possible to construct multi-card problems in which S is required to find every symbol subset that is associated with each card. These multi-card problems can be made more or less difficult according to the number of cards and the type of labels used. Problems which include only + all cards typically have given subjects the least difficulty. It has been found convenient (in order to limit the range of difficulty) to consider only problems which include at least one +all or one -all card.

There is a logical procedure for solving each problem. Consider the problem shown in Figure 2. The first +all card establishes logically that every symbol of each subset associated with this card must be one of: S1, B1, C1, L2, W2, T2. That is, each associated subset can contain only elements chosen from among these six symbols. The second +all card does not have any of the properties represented by the symbols B1, C1, W2, T2. Thus, each nonempty subset which goes with both of the +all cards must contain one or more of the remaining symbols, in this case, S1 and L2. The only subsets that go with both of the +all cards are [ S1], [ L2], and [ S1 L2]. No other subset will do. The subset [S1 W2], for instance, although going with the first +all card does not go with the second.

Since the +1 card has both of the properties indicated by the two eligible symbols, S1 and L2, the one-symbol subsets [ S1] and [ L2] are the only ones which go with the +1 card as well as with the two
The subset \([S_1, L_2]\), for example, although it goes with the two +all cards, does not go with the +1 card. By definition, exactly one of the symbols must agree; instead, both \(S_1\) and \(L_2\) agree.

Procedures for solving any multi-card problem may be obtained by a similar sort of analysis. Two more difficult problems are presented, with solutions, in Figure 3. The reader may find it instructive to solve the problems himself before looking at the solutions. Other variations are readily constructed.

APPLICATIONS

To date, the card material has been used solely to explore selected aspects of the teaching-learning process \((6, 7)\). Readiness, transfer, directness and meaning were the primary variables of concern. The manner in which the material was used in two of these studies is described below.

One study involved a comparison of two often used instructional methods, one called exposition \((E)\) and the other discovery \((D)\). In both classrooms, a large board, displaying all 64 cards, was in sight — this was found useful in introducing the material. Colored chalk was used to construct card problems on the blackboard.

In the E-classroom, the experimenter simply stated the card properties along with the symbol and subset meanings. Then, the +all relationship, between subsets and cards, was explained. This was done briefly and no student participation was elicited.

Next, the problem solving algorithm was shown and the steps made clear — little, if any, emphasis was given to the underlying rationale. \(Ss\) spent the remaining seventy percent of the class time \((70\%\text{ of } 67\text{ minutes})\) solving two and three +all card-problems. A competitive situation, pitting boys versus girls, was produced and the "practice" took place under conditions of high motivation.

In the D classroom, the experimenter did not tell the \(Ss\) anything directly. Questions were asked and hints were given which were designed to challenge and to aid the \(Ss\) to find systematic algorithms for solving the card problems. "How do these cards differ? \(S_1\) means the first object is small; what do you suppose \(L_1\) means? Has anybody figured out what makes a 'word' go with a +all card? Can anyone find a three-letter word" going with this (+all) card? Can anyone tell me how many associated two-letter words there are that go with these three +all cards?" These were typical questions; the purpose of the last was to induce the \(Ss\) to find systematic modes of attack. After the \(Ss\) generally had attained a good problem solving facility, the experimenter changed topics. He wrote six symbols on the board and asked the \(Ss\) to write all of the possible subsets containing these symbols. After the \(Ss\) realized how tedious the task was (there are 63 non-empty possibilities), the task was made simpler by crossing off one or more symbols. This technique was repeated until the \(Ss\) generally were able to attain every subset in an orderly fashion. When the \(Ss\) were asked, "Can anyone solve this problem by 'crossing out' symbols?" several of the best \(Ss\) caught on almost immediately — the idea spread rapidly. One more problem was given and the instruction concluded after 67 minutes.

Posttesting involved two short tests given after a short refreshment break. The first, a routine test, was composed of +all problems and was used as a measure of specific transfer. The second, a novel test, contained problems made up of both +all and -all cards and was used as a measure of non-specific transfer.

As is typical in classroom research, several variables were confounded. Nonetheless, by a careful post-analysis of tape-recordings of the classes, valuable insights into the interrelationships involved were obtained. These are reported elsewhere \((6, 7)\) and there is no need to repeat them here.

A similar study was conducted in the laboratory. Two groups of \(Ss\), pretimed \((P)\) and timed \((T)\), were trained and tested individually. The nature of the cards, symbols, and the relationships between them were described in the same manner to all \(Ss\). Group \(P\) \(Ss\) were shown the problem solving algorithm before having had an opportunity to attack a series of 10 problems while group \(T\) received the information afterwards. Both groups were tested for specific and non-specific transfer. Group \(P\) was slightly superior with regard to specific transfer, but group \(T\) transferred 50 percent more in the non-specific situation.

In other explorations, the card material has been taught for as long as five lessons of an hour each at grade levels ranging from the fourth to a college calculus class. Instructional time has been found to vary as a function of problem complexity, the kind of instruction given and the problem solving sophistication of the \(Ss\).

DISCUSSION

It is felt that the card material has important advantages over ordinary subject matter as a tool in educational research.

1. By serving to equate subject-pre-familiarity; thus, eliminating the need for pre- and post-testing; fundamental changes in behavior may be more readily detected.

2. The sequential nature of the card material and the many kinds of related problems that can be constructed from it make the material particularly well suited for use in research involving readiness and transfer. Both variables are fundamental to the teaching-learning process, but have always been somewhat elusive.
3. The card problems are similar to many problems confronted in the classroom, particularly the mathematics classroom. Thus, findings based on card-material-research may be more directly generalized to the classroom than have many laboratory results. By "simulating" the classroom learning of ordinary subject matter with novel material some educational problems may be explored with a relatively small expenditure of time and energy. Such an approach may make it possible to systematically collect a body of experimental data in much the same manner as has been done in the study of learning.

Furthermore, since the material appears to be applicable to the classroom and laboratory alike, researchers who are interested in both levels of investigation have a tool which may aid in the coordination of their work. Educational research may raise questions for more precise study in the laboratory and laboratory findings may be tested for application in the classroom in a more integrated manner than has been the case.

Although the card material, to date, has been exclusively employed to study the teaching-learning process, it shows promise in other areas of problem solving research. Application to studies involving problem complexity (2) and comparisons of problem solving ability at various age and ability levels (3) appear promising.

SUMMARY

Some abstract card material was described and its use illustrated in both educational and laboratory situations. Advantages in using the card material to simulate classroom situations and to aid in the coordination of educational and laboratory research were outlined.

FOOTNOTES

1. The collection of symbol subsets which satisfy this condition (i.e., of being associated with each card) may be called the "solution set".

2. The symbols denoting color were changed appropriately. The essential features of the card material may be presented in many ways. Maag's (4) solids are a case in point. For pedagogical reasons (the Ss were bright fourth and fifth graders), the symbols were called "letters", and the symbol subsets were called "words".

3. The -all relationship was explained to both groups in the same way just before the novel test.

REFERENCES

FIGURE 2
THREE-CARD PROBLEM, WITH SOLUTION SUBSETS AND PROBLEM SOLVING ALGORITHM SHOWN IN STAGES

- ALL, +1, AND -3 CARDS AND TWO ASSOCIATED SUBSETS FOR EACH

FIGURE 3
TWO THREE-CARD PROBLEMS, WITH SOLUTION SUBSETS AND PROBLEM SOLVING ALGORITHMS SHOWN IN STAGES