


An Empirical Study  
Comparing Three Problem-Solving Techniques

An Honors Thesis (HONRS 499)

by

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**Abstract**

A paradigm for problem-solving, the IDEAL model, is summarized and utilized as a model for discussing ill-structured problems (Bransford & Stein, 1993). The present study evaluated the effectiveness of three problem-solving techniques: brainstorming, taking other people's perspectives, and a hierarchical technique. The quantity, quality, and creativity of the solutions produced in each condition were evaluated. Brainstormers produced solutions of subjectively high creativity, yet failed to produce high quality. Explanations are given for this apparent incongruity. Subjects trained in the hierarchical technique produced more solutions, and ones of higher quality. Suggestions for future research are provided.

**An Empirical Study****Comparing Three Problem-Solving Techniques**

Many of the problems people face in life are ill-structured. That is, the methods for generating solutions may not be clear, there are many different solutions, and it may be impossible to objectively determine which is best (e.g., Butler, 1994; D'Zurilla, 1986; Osborn, 1953). For example, the present study asked subjects to generate solutions to a problem concerning a roommate. Subjects were asked to come up with all the possible things they could do if his/her roommate was dealing drugs. Some of the very different possible solutions are: talk to the resident advisor (R.A.) about the situation, move out without explanation, or ask roommate to let you in on his/her business. This problem is considered ill-structured because there is not ONE correct solution to the problem. In fact, people may differ in their judgments as to which is the best solution. Perhaps the decisions vary according to individual personality and experience.

**The IDEAL Model**

Bransford and Stein (1993) provide a model of how people should solve problems. This model may be useful for ill-structured problem-solving. The components of this model are represented in the acronym IDEAL. Each letter

stands for an element that is essential in the cycle of problem-solving.

**Identify.** The first component in this model is to IDENTIFY potential problems and view them as "opportunities to do something creative." (Bransford & Stein, 1993, p. 20) When problems are treated as opportunities for creative thought, the result can sometimes be a solution or invention that otherwise may have not been discovered.

**Define.** The second step in the model is to carefully DEFINE the goals in the problem situation. Different people often find different goals for a given situation. For instance, in the previous example concerning the drug-dealing roommate, one might define the goal as "get myself (physically) out of the situation." In this case, this individual would probably concentrate on finding ways to move him/herself out of the room. On the other hand, another person may define the goal as "get my roommate to stop this behavior." With that goal in mind, this person would concentrate on more active, confrontational strategies.

**Explore.** The third component of the IDEAL model of problem-solving is to EXPLORE possible alternatives to solving the problem. Bransford and Stein (1993) discuss four different strategies that can guide the exploring process.

The first of these strategies is the general systematic approach. This approach seems appropriate for structured problems (those that have one correct answer or goal). For example, to solve the problem, "What day follows the day before yesterday if two days from now will be Sunday?" Effective problem-solvers dissect the problem into simple parts: "1. What is today if two days from now will be Sunday? (Friday) 2. If today is Friday, what is the day before yesterday? (Wednesday) 3. What day follows Wednesday? (Thursday)" (taken from Bransford & Stein, 1993, p. 28) The problem thus becomes elementary when broken into parts.

The next approach for exploring alternatives uses a different kind of representation to facilitate keeping track of information. This approach uses external representations, such as Venn diagrams and graphs to simplify and organize the information. Bransford and Stein (1993) emphasize that the most effective way to represent information depends on the nature of the problem and how the problem-solver defines the goals.

The third approach to exploring alternatives is to use general strategies such as working backward or by focusing on a simpler, more specific situation (e.g., building a scale model).

The last approach for exploring alternatives is to

acquire specialized knowledge in the area of the problem and related areas, and be able to apply this knowledge to the specific problem.

**Anticipate and Act.** The next phase of the problem-solving model is to ANTICIPATE possible outcomes and ACT on the selected strategy. This phase of the IDEAL model can help reveal inappropriate assumptions that might be misleading thinking about the problem. An effective approach to anticipating outcomes is to imagine both worst-case and best-case scenarios.

**Look and Learn.** The final component of the IDEAL framework is to LOOK at the results of the strategy and LEARN from the experience. Each of these components, IDENTIFY, DEFINE, EXPLORE, ANTICIPATE/ACT, and LOOK/LEARN, create a cycle that problem-solvers may have to move through several times to arrive at a satisfactory solution.

The issues of ill-structured problem-solving considered in the present study mainly involve the DEFINE and EXPLORE stages of Bransford and Stein's (1993) model. The present research examined three problem-solving heuristics that may help people in these two phases of the IDEAL model. These three techniques are described at more length below.

### **Brainstorming**

Osborn (1953, 1979) believed people often terminate thinking of solutions too quickly. He developed the

technique called "brainstorming" to help people avoid quitting prematurely. The rules for the brainstorming technique are: generate as many solutions as possible, defer judgment about solutions until the end of the brainstorming session, come up with unusual ideas, and combine and build upon existing ideas. The problem-solving technique of brainstorming assumes that if a large quantity of solutions are created, there is a high likelihood that among these solutions an excellent one will be found to solve the problem.

#### **Others' Points of View**

Some people believe that taking different points of view helps people think of different solutions to problems. There is no empirical research supporting this hypothesis. However, there is some work in memory research that suggests that it may be a viable method.

Anderson & Pichert (1978) found the others' technique to be beneficial in memory recall. Subjects were instructed to take the point of view of either a home-buyer or a burglar and read a description of an old house. Subjects were then asked to recall as many details as they could. Half of the subjects taking each perspective were then asked to switch to the other perspective. Those who switched perspectives were able to recall more information than those who did not switch perspectives.

Fisher and Geiselman (1988) have also found evidence that taking other people's perspectives can be beneficial for memory recall. Their research utilized the "cognitive interview," which is a method for questioning witnesses to a crime. During this procedure, witnesses are asked to report events that occurred from a variety of perspectives. This procedure is intended to aid witnesses in recall of more accurate details, while also decreasing the number of inaccurate details that might otherwise be given. Their results indicated that taking multiple perspectives does facilitate memory recall.

#### **Hierarchical Technique**

The hierarchical technique (Butler, 1994; Vanhorn, 1994; Thomas, 1993) is a relatively new problem-solving technique. Subjects are trained to build hierarchies with superordinates (general categories) of solutions at the top and subordinate solutions (more detailed solutions) below. The technique begins by having the solver generate an initial list of solutions. They then search this list to find solutions that have something "in common." The commonality is used to generate a general category of solutions. Then, the problem-solver produces other solutions from this commonality. See Figure 1 for an example of a hierarchy of solutions to a problem about making money.

The hierarchical technique is a visual as well as verbal technique. In the training of this technique, the experimenter instructs subjects to draw something like a box around each idea, then to interconnect these ideas by hierarchically arranging and connecting the ideas. The creating of hierarchies is not considered rigid, as subjects are told to create the hierarchy as it makes sense to the individual, not necessarily making perfect sense to someone else who might look at it. The idea is that through using the process/guidelines of building the hierarchy, novel and good solutions will be created. This technique uses a visual representation, which is recommended by Bransford and Stein (1993), and this allows the solver to create a meaningful representation of relationships and ideas. It also breaks the problem into categories and subcategories, and, in doing so, tends to redefine the problem several times without the solver even realizing it!

Other researchers (Dufrense, Gerace, Hardiman, and Mestre, 1992) have found that novices who are trained in hierarchically structured problem analysis solve problems more effectively than students using only student-directed problem-solving activities. Dufrense et al. (1992) theorize that experts use a top-down approach whereby they perform a qualitative analysis to identify the main principles, concepts, and procedures. Only after these general

categories are identified do experts then attend to applying the details to solve the problem. After using a computer based tool called Hierarchical Analysis Tool (HAT), novices' judgment showed greater agreement with those judgments made by experts.

### **Purpose of Research**

One purpose of this research is to compare the effectiveness of the three problem-solving techniques: brainstorming, the others technique, and the hierarchical method. The number of solutions generated before and after training was evaluated. Whether subjects' perceived best solution occurred before or after training was evaluated. Also, whether subjects' perceived most creative solution occurred before or after training was evaluated.

Previous research in problem-solving (Butler, 1994; Butler, Thomas, Vanhorn, and Pickel, 1994; Vanhorn, 1994; Thomas, 1993) found that the hierarchical technique produced higher quality solutions. It was therefore hypothesized in the present study that the hierarchical technique would produce more "best" solutions after training than the others' and brainstorming techniques would. This hypothesis was also based on the fact that brainstormers are instructed to come up with as many wild, unusual solutions as they can rather than realistic or practical ones. Therefore, the quality of the brainstormers' solutions should not be as

high as the quality of subjects' solutions using the hierarchical technique.

A study done by Butler et al. (1994) indicated that subjects using the others' technique produced significantly less solutions after training than both brainstorming and hierarchical groups. Also, subjects in the others' conditions tended to choose their best solution before training.

An objective of the present study was to critically evaluate and compare the recently studied hierarchical technique to the popular, well-known technique of brainstorming. The present study is also exploring the notion of subjective creativity, as there has been no previous research on ill-structured problem-solving which had subjects using various heuristics evaluate the creativity of their solutions.

## **Method**

### **Subjects**

Subjects were 102 undergraduate students enrolled in introductory psychology classes at Ball State University who volunteered to be subjects in the experiment.

### **Procedure**

Subjects were randomly assigned to one of the three experimental conditions. Subjects met in small groups.

Subjects in each condition were given an interpersonal problem:

"Imagine you are a freshman at a university... You've been getting along pretty well with your new roommate. There is one problem, though...one day you catch your roommate dealing drugs...Try to think of all the possible things you could do in this situation. Write these solutions on the blank paper provided." (See Appendix 1 for the entire problem.)

Subjects were told to generate as many answers to the problem as they could, and were given fifteen minutes to work on the problem. They were not told that they would be coming back to the problem later on in the experiment. Subjects worked independently, utilizing a large (11" x 17 1/2") piece of paper and a black pen. After the initial generating phase, subjects' pens were collected, and the training phase began.

Subjects in each condition were trained for approximately fifteen minutes concerning the rules for and how to use the respective problem-solving technique (See appendices 3, 4, and 5 for part of the training given). The experimenter used a different problem than the initial one to demonstrate the technique:

"Chris needs \$300 to pay for damages to her dorm room. She has one month to come up with the money or she will be

evicted. Think of as many different ways as you can that she could solve this problem."

During the training for all three conditions, the same overhead was used for the sample problem. This overhead also included ten sample solutions that had been generated. (See Appendix 2 for this overhead.) The purpose of the sample items was to facilitate training. Training the subjects with a few sample solutions made good sense, since the subjects would later be returning to the original problem with some initial solutions to add to, and, in the hierarchical condition, to build from.

After training, the overhead of the original (roommate) problem was put up. Subjects were instructed to create as many new solutions as they could, using what they had learned in training. Subjects were given red pens to complete the last phase of solution-generating to set these new answers apart from the initial solutions. Subjects, still working independently, were given twenty minutes to generate as many new solutions as they could.

At the end of twenty minutes, subjects were instructed to look through all of their solutions and locate the one that they believed was the overall best solution, and the one solution that was the most creative solution. Subjects designated these solutions by circling them and also writing them in the lower right-hand corner of the paper.

## Results

### Quantity

Figure 2 shows the number of solutions generated by the three groups before and after training. As you can see, the groups did not differ in number of solutions generated before training. However, the effect of training led to substantial differences. There was a main effect of group: ( $F(2,86)=22.66, p<.0001, \eta^2=20.3\%$ ), main effect of time: ( $F(2,86)=30.02, p<.0001, \eta^2=6.5\%$ ), and an interaction of group and time: ( $F(2,86)=35.26, p<.0001, \eta^2=15.2\%$ )

### Quality

Training also affected the quality of solutions. Whether the best solution was chosen before or after training is summarized in Figure 3. Differences were significant ( $X^2(2)=5.92, p<.05$ ). After training, the number of BEST solutions chosen from the hierarchical group was significantly different from number chosen from the brainstorming group ( $X^2(1)=6.04, p<.02$ ). Subjects in the hierarchical condition were about five times more likely to choose their best solution after training than subjects in the brainstorming condition.

### Creativity

Training also affected the creativity of solutions. There were significant differences across groups concerning when the most creative solution occurred ( $X^2(2)=8.59,$

$p < .02$ ). All of the techniques seemed to somewhat encourage creativity. However, subjects in the brainstorming group were more likely to choose their most creative solution after training than those subjects in the hierarchical condition ( $X^2(1) = 6.21, p < .02$ ) and those in the others' condition ( $X^2(1) = 7.96, p < .01$ ). See Figure 4 for a summary of when the most creative solution occurred.

### **Discussion**

The focus of this study was to (1) compare the number of solutions generated before and after training, (2) evaluate each condition on whether subjects chose their best solution before or after training, and (3) evaluate each condition on whether subjects chose their most creative solution before or after training. After collecting this data, the goal of this study was to critically evaluate the usefulness of each of the three techniques.

This experiment showed differences in the effectiveness of three problem-solving techniques that can be used for generating solutions to ill-structured problems.

#### **Brainstorming**

Brainstormers succeeded in producing subjectively more creative solutions, but were much less productive in achieving best solutions. Previous research may have one explanation for the brainstormers' solutions not being as

high in quality as the subjects' solutions in the hierarchical condition. Weiskopf-Joelson & Eliseo (1961, cited in Thomas, 1993) found that groups who were instructed to generate unusual ideas were less productive than groups who were instructed to generate practical ideas.

A creative solution entails novelty AND good quality (Bransford & Stein, 1993), yet brainstormers did not appear to consider quality as that important in determining creativity. The experimenter did not operationalize the definition of creativity for subjects. It is possible that subjects in the brainstorming condition (as well as the other two conditions) were considering only novelty when choosing the "most creative" solution. In fact, some authors (e.g., Nadler, Hibino, & Farrell, 1995, p. 244) suggest that the definition of creativity that is used by most people is the "generation of unusual and innovative ideas." Therefore, the solutions chosen as most creative in the brainstorming group may have been quite novel, yet not very practical or useful.

In future studies, a creativity scale should be developed. Such a scale could include the recommended indices of novelty and practicality (Bransford and Stein, 1993) to operationalize and get a more accurate measure of creativity.

**Others' Points of View**

Subjects in the others condition did not score highest on any of the dependent variables. This condition did not have any outstanding characteristics that set it apart. These results are consistent with previous findings (Butler et al., 1994; Butler, 1994).

**Hierarchical Technique**

As in the Vanhorn study (1994), this study found that the hierarchical technique led to the generation of more solutions than the brainstorming method, and, in this study, the others technique as well. Subjects trained in the hierarchical technique in Vanhorn's study (1994) also produced solutions of subjectively higher quality than those in the brainstorming method. In the present study, subjects in the hierarchical group chose their best solution after training significantly more often than did brainstormers.

As far as the quality of solutions, the hierarchical technique was superior to the other techniques. Since successful problem-solvers are likely to define their goals in a number of different ways (Bransford & Stein, 1993), it is not surprising that the hierarchical technique succeeded in a high percentage of BEST solutions. By its very nature, the hierarchical technique guides and allows the solver to define and redefine the problem and its goals many times in the cycle of problem-solving.

The hierarchical technique gives a systematic approach to solving the problem by using the EXPLORE stage in a novel, meaningful way that effectively aids in memory recall. Previous research (Thomas, 1993) discussed that fixating on generated solutions can block the solver's ability to search memory for more solutions. However, even though the hierarchical technique uses previously generated solutions, the technique successfully provides a means to come up with more solutions, and good solutions as well, as indicated by the results of this and other (Vanhorn, 1994) experiments.

Other areas of research (e.g., Kiewra, 1989) besides problem-solving have found that hierarchically arranged systems can be useful. Kiewra (1989) found that students who took notes using a hierarchically organized format performed better on exams than did those students who took notes organized in an outline form or random form.

Considering the present findings and the recent research (Vanhorn, 1994; Butler et al., 1994; Butler, 1994; Thomas, 1993), the hierarchical technique is proving itself to be a generalizable problem-solving technique. Different researchers (e.g., Gick & Holyoak, 1980, cited in Butler et al., 1994) have found that people are not very successful at transferring training procedures from one problem to another. However, the hierarchical technique has been

successful using relationship problems (Butler et al., 1994; Thomas, 1993; Butler, 1994), financial problems (Butler et al., 1994; Vanhorn, 1994), and University campus issues (e.g., what to do about motorized vehicles on campus, in Butler et al., 1994 and Butler, 1994).

Along with the previous research, this study indicates that the hierarchical technique of problem-solving may have practical uses in a wide variety of settings. More studies should be undertaken, however, to answer some of the questions concerning the creativity of solutions.

Also, research designs could be implemented which have subjects work on a problem, then receive training on a problem-solving technique, then receive a different problem. Current research (Butler et al., 1994; Butler, 1994; Vanhorn, 1994; Thomas, 1993) has only used the design that was used in the present study. Using a different problem post-training would improve the validity, as the present design actually incorporates incubation into the three conditions. Incubation is a passive problem-solving strategy in which the solver puts the problem aside to return to it later, hoping that after the passage of time, a new insight may be gained. Smith and Blankenship (1991) argue that incubation allows people to forget about confusing or poor ideas.

In addition to the Problem A--training--Problem B

design that could be implemented, a post-test only design could be attempted. Subjects could immediately be trained on a problem-solving technique. Then, a problem different from an example problem could be utilized for the critical test. This design would also eliminate any effects of incubation. A post-test design would also make the critical test in the three conditions more equal, since the present design allows the solver in the hierarchical condition to use and add to the initial solutions.

Different populations and problems could be utilized to further test the extent to which the techniques generalize. Other studies could test the effectiveness of the hierarchical method on a wider range of populations, as the present study only included college students. Problems concerning business and commerce could be utilized to test if the technique is generalizable to the business industry. People working in the business industry could also be asked to try out the technique and evaluate its effectiveness.

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**Appendix 1. Interpersonal problem subjects initially generated solutions to, then worked on after training in all conditions.**

Imagine you are a freshman at a university. It is about the fourth week of the semester. You've been getting along pretty well with your new roommate. There is one problem, though. Many people stop by to see your roommate for only short periods of time, and then leave quickly. They seem uncomfortable with you in the room. Then one day you catch your roommate dealing drugs. Pondering the possible consequences of your roommate's activities, you wonder what you should do. Try to think of all the possible things you could do in this situation. Write these solutions on the blank paper provided.

**Appendix 2. Practice problem used by experimenter to demonstrate the problem-solving technique in each condition.**

Chris needs \$300 to pay for damages to her dorm room. She has one month to come up with the money or she will be evicted. Think of as many different ways as you can that she could solve this problem.

borrow money from parents  
get a part-time job  
charge it on a credit card  
sell stereo  
steal money from someone  
set up a payment plan  
try to fix damages herself  
borrow money from a bank  
babysit  
sell car

**Appendix 3a. Introduction to brainstorming given by the experimenter and shown on an overhead.**

### **BRAINSTORMING**

Many times when people are solving problems they judge the quality of their solutions too soon. For example, in the problem you just solved, you may have not written down ideas that you thought were dumb. Brainstormers believe that by waiting to judge the quality of your solutions until later, you will come up with many more solutions, and perhaps more creative solutions.

**Appendix 3b. Rules for brainstorming explained by the experimenter and illustrated on an overhead.**

**Rules for BRAINSTORMING:**

1. DEFER JUDGMENT

Postpone judging the quality of your solutions until the end of the brainstorming session.

2. QUANTITY IS IMPORTANT

Generate as many ideas of solutions as you can. The more ideas you come up with, the better are your chances of generating a GOOD solution.

3. ORIGINAL IDEAS ARE ENCOURAGED

Wild, unusual, and unique ideas are desired. Write down ALL ideas that come to your mind, no matter how silly they might be.

4. COMBINE AND BUILD ON EXISTING IDEAS

After you have finished generating initial ideas, go back over your list to see if you can combine on any existing ideas to create new ones.

**Appendix 4a. Introduction to the others technique  
given by the experimenter and shown on an overhead.**

**THE OTHERS TECHNIQUE**

Many times when people are solving problems they limit themselves by taking only one point of view. For example, in the problem you just solved, you may have only taken your own point of view. But there may be other useful points of view. Sometimes, by considering other points of view, you can discover a solution that is very different or unique. We believe you can take advantage of switching points of view to help you as you solve problems.

**Appendix 4b. Rules for the others technique given  
by the experimenter and shown on an overhead.**

**Rules for "OTHERS"**

1. Think of a person other than yourself.
2. Then, ask yourself if you were that person, how  
would you solve the problem.
3. Keep thinking of all the possible people  
you know, and return to step 2.

**Appendix 5a. Introduction to the hierarchical technique given by the experimenter and shown on an overhead.**

**HIERARCHICAL**

Many times when people are solving problems, they have the feeling that they should be able to list more solutions, but they can't think of any. We call this "hitting the wall." This may have happened to you when you worked on this problem. We believe the method called the "up-down" or "hierarchical" technique can help break through that wall by helping you search memory more effectively.

**Appendix 5b. Rules for the hierarchical technique explained by the experimenter and shown on an overhead.**

**Rules for HIERARCHICAL technique:**

1. Generate solutions.
2. Look for "general ideas" by searching your solutions to find ones that have something in common.
3. Generate new types from the commonalities.

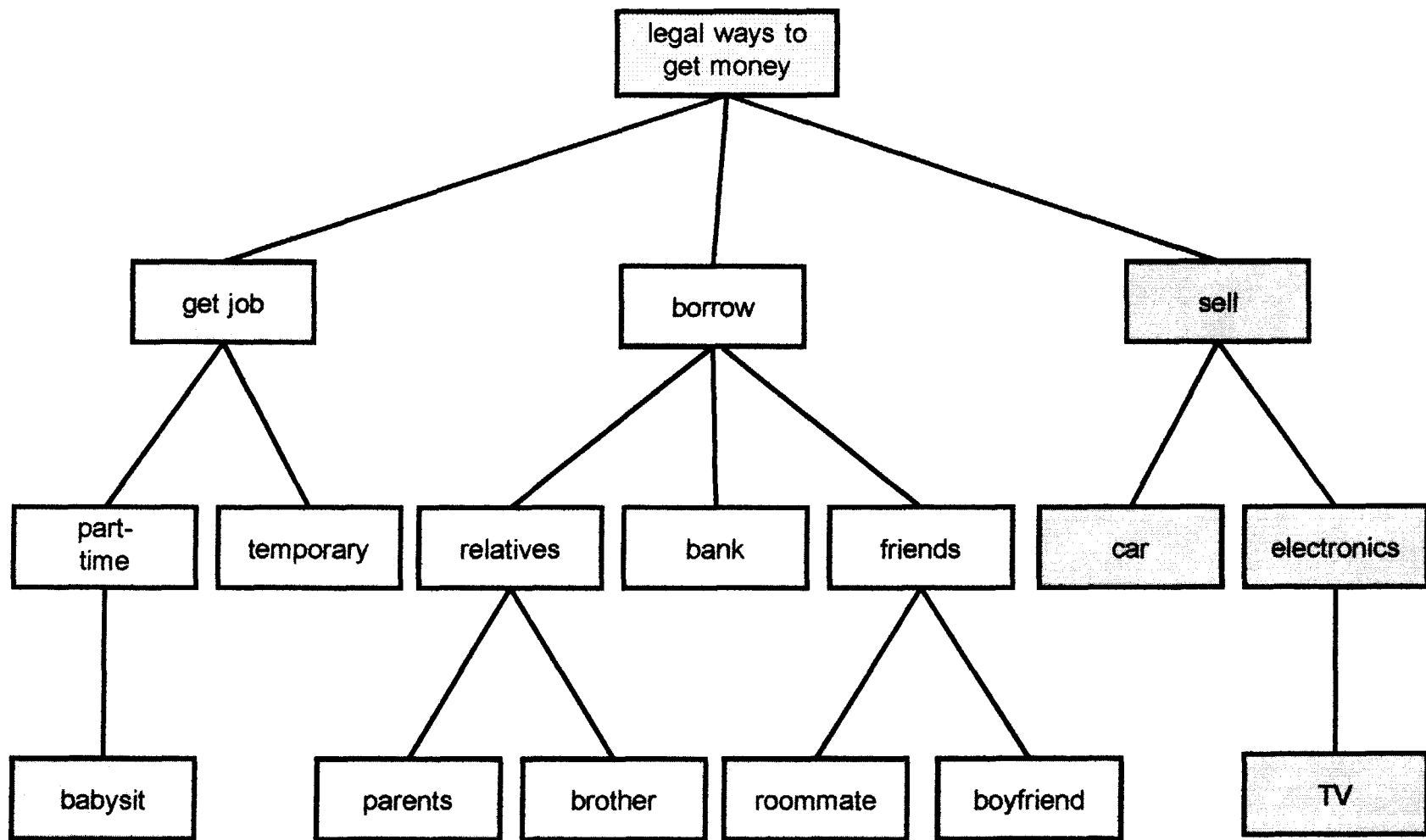
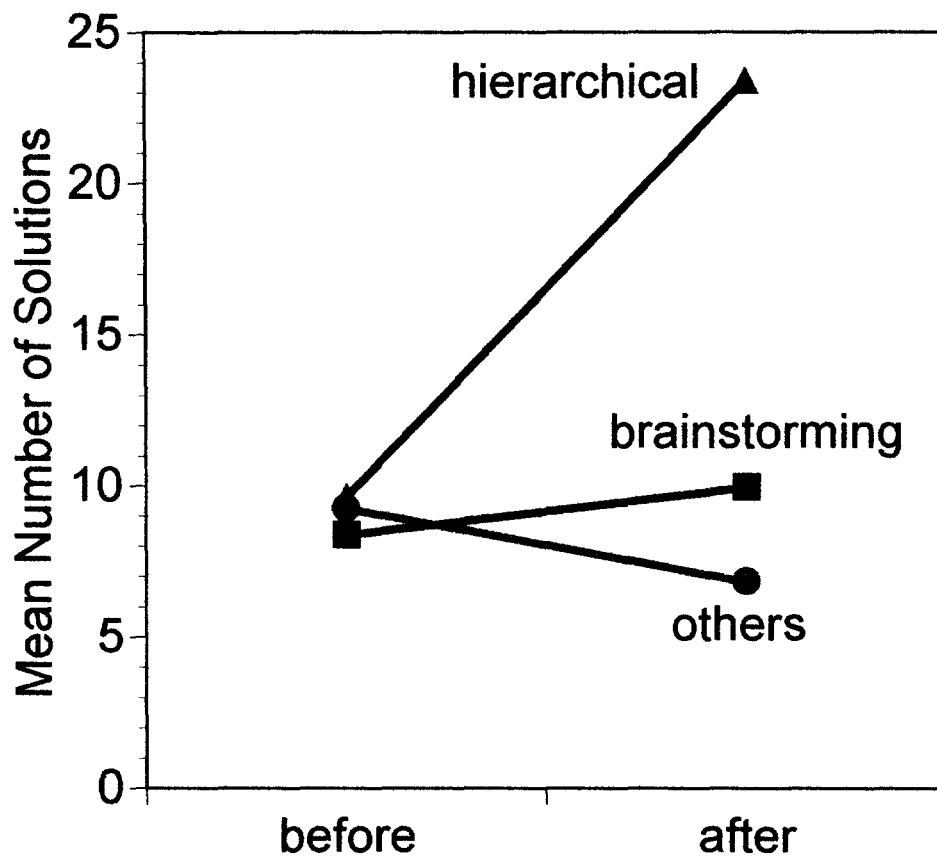
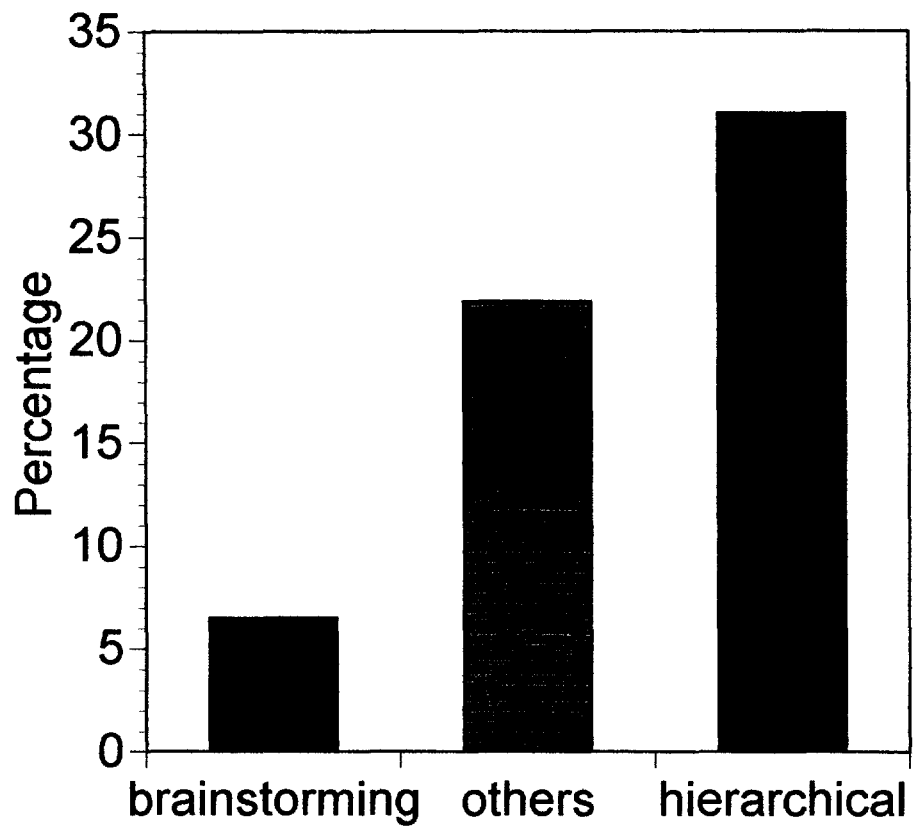


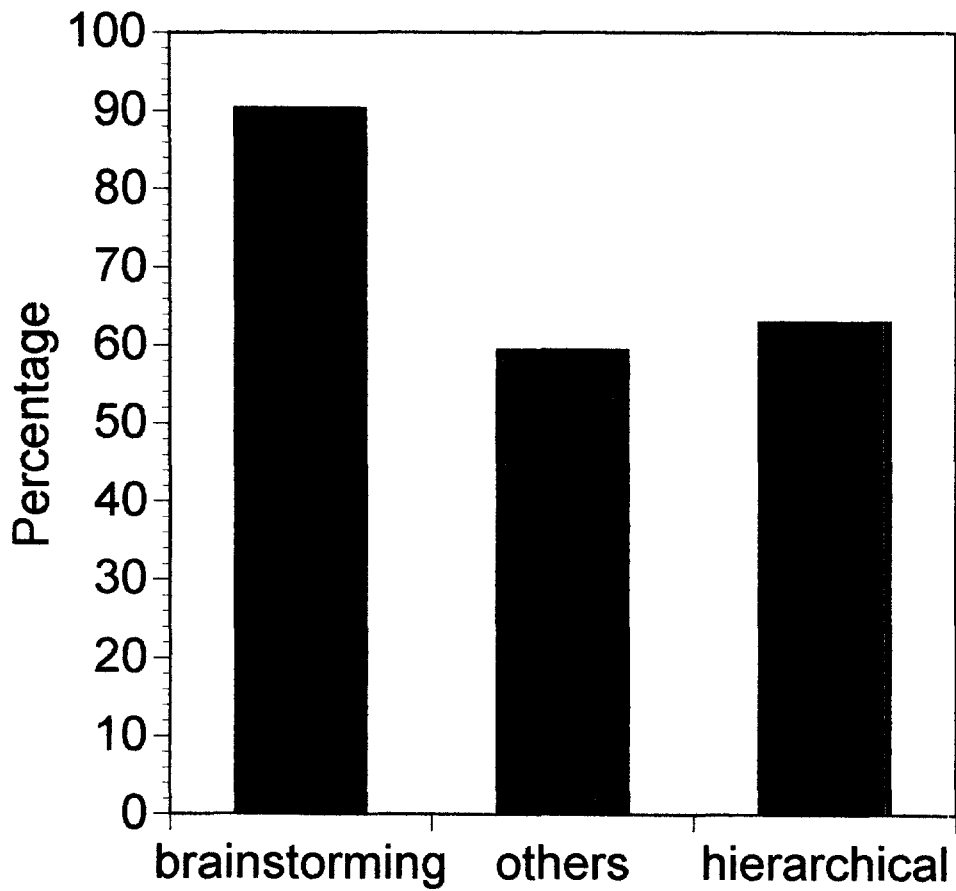
Figure 1: Part of Solution Hierarchy to Practice Problem



**Figure 2: Mean Number of Solutions Before and After Training**



**Figure 3: Percent of Time Best Solution Chosen After Training**



**Figure 4: Percent of Time Most Creative Solution Chosen After Training**