Reliability of Solutions and Problem-Solving Strategies

in Ill-Structured Problems

An Honors Thesis (HONRS 499)

by

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Abstract

Techniques for generating solutions have been the primary focus of research for ill-structured problems. An important issue, for which there is little research, is how to measure attributes of solutions, such as their quality. This experiment was designed to test the reliability of student's ratings of their solutions to an ill-structured problem, and to compare two problem solving techniques, brainstorming and hierarchical.

Brainstorming has four main rules: defer judgment of ideas, generate as many ideas as possible, write down all ideas, and combine and build on existing ideas. The rules for hierarchical method are: find "general" categories of solutions to the problem, generate new ideas that are "types" of these general categories, and consider the opposites of ideas and general categories. Both of these techniques were used to facilitate the generation of solutions to a problem. Results of this study indicated the number of solutions generated was different for those that brainstormed and those that used the hierarchical technique.

The results also indicated that the measure of reliability of students solution ratings was statistically significant, but not extremely high. This finding of reliability suggests that in other studies employing participant solution ratings, those ratings were reliable.
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Many of the problems that people encounter in their everyday lives are ill-structured. Ill-structured problems can have many different solutions, and often they present no right or wrong answer. Most ill-structured problems have unclear or undefined goals (Gick, 1986; Simon, 1973). For example, an ill-structured problem would be a problem such as: “You are having problems with your roommate, because he does not clean up his part of the room. How could you solve this problem?” There are several solutions here, and there is not a specifically correct answer. For example, the person could move out, talk to the roommate about the problem, or clean it up yourself. All of these solutions would solve the problem. Structured problems are different in that they have only one correct solution. For example, in a structured problem such as “A + 2 = 6”, the only correct way to solve this problem is A = 4.

Problem solving strategies that often work with structured problems do not often work with ill-structured problems. The main reason is that heuristics for well-structured problems require a clear final goal, and that is often what is lacking in ill-structured problems. Two of the heuristics used in ill-structured problem solving are brainstorming and the hierarchical method.

Solution Generating Strategies

Brainstorming has been seen by many as a popular way to generate a large number of ideas in groups (Gallupe, Bastianutti, & Cooper, 1991). There are four main
rules when using brainstorming: defer judgment about ideas, generate as many ideas as possible, write down all ideas, and combine and build on existing ideas. Osborn (1953, pp. 228-229) claimed that “the average person can think up about twice as many ideas when working with a group than when working alone – unless the individual ideators adhere to the brainstorming principle of suspended judgment”. But other studies show differently. The majority of published studies show that groups of four or more people produce significantly fewer ideas than individuals generating ideas on their own (Gallupe, Bastianutti, & Cooper, 1991). Nevertheless, brainstorming has been found useful to solution generation and has also been found to be helpful in the enhancement of individual problem solving creativity (Sappington & Farrar, 1982).

The hierarchical method of problem solving, as proposed by Butler and Thomas (1998), involves organizing ideas into a hierarchy. The rules for this heuristic are: find “general” categories of solutions to the problem, generate new ideas that are “types” of these general categories, and consider the opposites of ideas and general categories. This technique has been shown to produce more solutions ranked higher in quality than brainstorming (Butler & Kline, 1998).

Evaluating Solutions

How does one decide the relative impact of strategies on ill-structured problem solving? This is not an easy question to answer. Unlike well-structured problems, typically there are few objective measures. One objective measure is the number of solutions generated. This measure has been used by many researchers (Butler & Thomas, 1998; Butler & Vine, 1998; Osborn, 1953). However, number alone does not address
qualitative aspects of solutions. A common approach for measuring quality is to use judges. The advantage of using judges is that they are more objective than the subjects. The disadvantage is that they may not have information about the solutions that the individuals would have. Another approach is to let individuals rate their own solutions. Advantages of this approach are that individuals can understand their own solutions better than judges, and since they thought of the solutions, they may have some insight which judges may not. There are disadvantages however, in that the individuals may have a certain attachment to some solutions over others.

In several studies done by Butler (1998), students have been asked to rate their solutions on various scales at the end of the experiment. Some scales that have been used to rate solutions in previous studies are: number of solutions, quality, originality, creativity, practicality, and goodness.

The practicality of solutions is a measure of how practical each solution would actually be if applied to the problem in reality. Solutions that are not practical would be ideas that the person would not consider using in real life, possible due to illegality or expense. Practical solutions are those that solve the problem without creating further problems, can be done, are legal, and affordable. The rating of practicality has been shown to be significantly higher for subjects trained for in the hierarchical than for those trained in brainstorming (Butler & Vine, 1998).

The originality of a solution is defined as the relative frequency of subjects who generate the same solution. The measure of originality depends upon the raters judgment of how many people probably could come up with the idea. Generally, a solution rated high in originality would be more creative and novel than other solutions. Unoriginal
solutions are ideas that would be thought of by anyone trying to solve the problem. Problem solvers using the brainstorming heuristic have been shown to rate their solutions significantly higher in originality than problems solvers using the hierarchical technique rated theirs (Butler & Vine, 1998).

To rate a solution on a scale of general goodness, the rater must look at the overall quality of the solution in general. General goodness should suggest how good the solution would be to the average person with this problem. Although this rating scale gives a good indication of the overall quality of the solution, it does not indicate personal goodness. Personal goodness is an indication of how good the solution would be for the problem if it were a real problem to the rater. General goodness is what judges might use to rate solutions, whereas ratings of personal goodness may include unique information not available to judges. The use of both of these scales in solution rating differs from other research in that most research in this area uses only a rating of quality or goodness. The purpose of using this different approach is to find whether participants view solutions good for them as being good for anyone, or whether they view solutions in a more personal nature.

**Purpose of the Study**

There are three purposes to this study. The first is to investigate the relations among measurements of people's solutions to ill-structured problems made at different times. Researchers need to know if self-ratings are reliable. The second purpose is to compare two different measures of quality, generally for everyone and a personal quality. Differences would indicate an important issue for reliability and validity of ratings of
solutions to ill-structured problems. The third goal is to examine the effectiveness of two different problem-solving strategies. This aspect of the study is a replication of previous work.
Method

Subjects

Subjects were 84 undergraduate students attending Ball State University. Participants were obtained from the psychology research pool in the Department of Psychological Science here at Ball State University. We followed the department’s normal procedures and all students received course credit for their participation. The participants were between the ages of 18 and 22.

Procedure

Each participant was given the following problem and asked to generate as many solutions as they could in 20 minutes:

"You have a group project for a course in your major that is worth 25% of your course grade. There are three people in your group. One person hasn't been carrying his/her share of the load and it doesn't look like two of you can do all the work on time. You are worried that it will have a big effect your grade and on the professor's opinion of you. What can you do?"

Following this first generation period, the researcher taught the participants a problem solving technique. There were two kinds of techniques, brainstorming and hierarchical. Participants were assigned to a technique randomly, with the restriction that there were approximately the same number of participants for each technique. The participants then worked on the following sample problem, one used in prior research, to practice the technique.
Chris needs $300 to pay for damages to his dorm room. Chris has one month to come up with the money or be evicted. Think of as many different ways as you can that Chris could solve this problem.

Once they had demonstrated their understanding of the technique, they were asked to return to the original problem and use the problem solving technique to generate more solutions. When the participants had completed generation, they were asked to rate their own solutions on four rating scales: personal goodness, general goodness, originality, and practicality. All four rating scales ranged from one to seven. The end anchors of the scales were defined using terms that would generally describe the scales in words that the participants would easily understand. The following end anchors were provided:

**practicality**
- 1 = impossible, illegal, or otherwise not feasible
- 7 = possible, legal, affordable, and appropriate,

**originality**
- 1 = very common – “everyone would think of this”
- 7 = very unusual – “I’m probably the only one who thought of this”,

**personal goodness**
- 1 = “this is a very bad idea for me”
- 7 = “this is an excellent idea for me”

**general goodness ranging**
- 1 = “this is a very bad idea for most people”
- 7 = “this is an excellent idea for most people”.
Finally, the participants were asked return at the same time one week from the original date. Those that returned rated their solutions again on the same scales.
Results

Hierarchical vs. Brainstorming Effects

The number of solutions generated was different for those that brainstormed and those that used the hierarchical technique. The number of solutions was counted for each participant by examining the number of solutions rated by each student. The mean number of solutions for those using the brainstorming technique was 12.26, and the mean for those using the hierarchical technique was 8.46. The difference in number of total solutions between these groups was statistically significant ($F = 10.45, p<.01$).

Means were computed for ratings of solutions that were generated after learning a problem solving technique. These means (shown in Table 1) were compared between the two techniques, using ANOVA and t-tests. There were no significant differences found between the two techniques on any of the rating scales.

Personal Goodness versus General Goodness

Participant ratings of personal goodness and general goodness from both techniques were compared using Pearson correlation coefficients to see if there was any correlation between the two. The means of each rating were used to find that $r (84) = 0.844$, $p < 0.001$. The correlation between the two ratings scales is significant.

Reliability

Only 42 participants returned in one week, and only their data was used to examine reliability. Pearson correlation coefficients were computed on the ratings of solutions before and after a one-week period. The correlation coefficients for each scale
were as follows: practicality, $r (40) = 0.629; p < 0.01$; originality, $r (40) = 0.667, p < 0.01$; personal goodness, $r (40) = 0.62; p < 0.01$; and general goodness, $r (40) = 0.693, p < 0.01$. 
Discussion

Participant ratings in this study were reliable. This finding indicates that people rated their solutions approximately the same before and after the one-week incubation period. The implications of this finding have a large impact on studies done in this area, particularly studies in which participants rated their own solutions. In many problem-solving studies, participant ratings have been used as results. The finding of reliability of participant ratings suggests that in other studies employing participant solution ratings, those ratings were reliable.

However, the correlations were not extraordinarily high given that means were used. Future research is necessary to determine whether judges are more or less reliable. These studies will be essential to the research in this area, because it is important that researchers find the most valid and reliable measures that they can to use in further problem solving research.

Differences in quantity of solutions between the two problem-solving techniques was also statistically significant. Participants who were taught the brainstorming technique produced significantly more solutions than participants who were taught the hierarchical technique. This suggests that learning to use brainstorming in problem solving facilitates the production of a greater quantity of solutions. This result is different from prior research. The cause of this result could be that since brainstorming has been found to produce more creative solutions (Butler & Thomas, 1998), it helps to generate a greater quantity of solutions overall.
The correlation between ratings of personal goodness and ratings of general goodness was significant, though not to a high degree. This result indicates that participants often viewed solutions that were good for them to be good for anyone with that problem. This finding is important because there was no known data pertaining to the use of two goodness ratings before this study was done, and now we have some idea of the effect of personal judgment in rating the quality of a solution.

One surprising result of this study was the lack of significant differences between solutions generated after learning one of the two problem-solving techniques. Using the ratings given by the participants, the data suggests that there is no statistically significant difference between the mean values on each scale for post-technique solutions. This could suggest one of several things. One, the problem used in this study was too limiting. Perhaps students could imagine very few solutions regardless of the training. This would explain both the relatively low number of solutions generated and the similarity of ratings between the two training groups. Another possibility is that subjects lacked motivation to use the techniques. If participants did not use the techniques to their full potential to generate solutions, then they would have generated relatively few solutions and differences between training groups would be subtle.

This study found that self-ratings are reliable, that personal goodness ratings are different from general goodness, and that the kind of training does have effects on the solutions to ill-structured problems. But there is still much research to be done in the area of problem solving in psychology.
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Behavior, 16*, 68-73.

181-201.
Brainstorming Technique

In this experiment, we will show you a problem solving technique and let you practice it. These instructions will introduce you to the technique.

Consider the following problem:

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

Assume that a person came up with the following list of ideas:

- Borrow money from parents
- Sell car
- Sell TV
- Borrow from brother
- Get a temporary job
- Babysit
- Get a part time job
- Borrow money from a friend
- Borrow from the bank

When people are generating ideas, after a while they often cannot think of any more ideas. One technique that may help a person to continue to generate ideas is called brainstorming. There are four simple rules:

**Rule 1: Defer Judgments**

Do not judge ideas until you have thought of as many as possible. Sometimes people cannot think of other ideas because they are too critical of the ones they generate. Try not to be. Think of possibilities. Sometimes poor ideas can lead to really good ideas. Don’t dwell on unrealistic quality; try to think of other ideas.
Rule 2: Generate as many solutions as you can
Try to think of as many solutions as you can. The more you can think of, the better your chances of thinking of one you will think is best. In the list above, there are only nine solutions. That really isn’t very many. Write down three ideas of your own that could solve Chris’s problem.

Rule 3: Write down all of your ideas
Many people refuse to write down some ideas. It is okay to include wild, unusual, and unique ideas. Sometimes unique ideas are desirable. Sometimes they are stepping stones to really great ideas. For example, a person who thinks of selling a TV, may think of selling their blood.

Rule 4: Combine and build on existing ideas
If you get stuck, go back over the ideas you have produced to see if you can combine any of them to make new ideas. For example, in the list of solutions above, we might combine two for the idea of getting a part time job at a bank.

Keeping these rules in mind, discuss with the experimenter three of you own ideas. After the discussion, continue with the instructions.

Here are the rules of brainstorming again:

Rule 1: Defer Judgment
Rule 2: Generate as many ideas as you can
Rule 3: Write down all of your ideas
Rule 4: Combine and build on existing ideas

Now go back to your original problem and use the brainstorming technique to try and generate more solutions.
Hierarchical Technique

In this experiment, we will show you a problem solving technique and let you practice it. These instructions will introduce you to the technique.

Consider the following problem:

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

Assume that a person came up with the following list of ideas:

- Borrow money from parents
- Babysit
- Sell car
- Get a part time job
- Sell TV
- Borrow money from a friend
- Borrow from brother
- Borrow from the bank
- Get a temporary job

When people are generating ideas, after a while they often cannot think of any more ideas. One technique that may help a person to continue to generate ideas is called the hierarchical technique. There are three simple rules:

Rule 1: Find “general” solutions

There are several ways to discover general solutions. One way is to examine solutions to see if two or more have something in common. There are at least three general solutions that can be found in the list above. Please try to find three general solutions now.
You may find it helpful to graphically organize your solutions as follows:

SELL
  /  \
 /   \
 sell car  sell TV

Put related ideas next to each other and connect them with lines.

Rule 2: Generate new ideas that are types of the general ones

Once you have organized your ideas, most people find it easy to think of other ideas that are examples of the general categories. See if you can add one or two ideas of your own to each of the general ideas.

Rule 3: Consider opposites of ideas

Sometimes you can come up with good ideas if you consider the opposites of ideas (especially general categories). For example, the opposite of borrow is loan. Perhaps Chris could make some money by loaning something.

Here are the basics of the hierarchical technique again:

Rule 1: Identify general ideas

Rule 2: Generate new ideas that are examples of the general ones

Rule 3: Consider opposites of ideas